Faculty of Arts
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CONTINUITY AND DISCONTINUITY IN EARLY, MIDDLE AND LATE NEOLITHIC POTTERY TYPES OF EASTERN FENNOSCANDIA

Reflections from Bayesian chronologies

Petro Pesonen

DOCTORAL DISSERTATION

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ABSTRACT

The focus of this dissertation is on eastern Fennoscandian Early, Middle and Late Neolithic pottery types and their chronologies. The study presents and evaluates the available radiocarbon dates connected with these types and builds a radiocarbon chronology with the help of Bayesian statistics, i.e. using model building to define the starting and ending boundaries for pottery type phases. The phases are also visualized through summed probability distributions of the radiocarbon dates. Birch bark tar used as a repair material and charred food crust in the pots themselves form the most reliable group materials for deriving radiocarbon dates and are furthermore directly connected to specific pottery types. Several error sources within the corpus of radiocarbon dates are evaluated, and the marine reservoir effect (MRE) is specifically considered problematic for charred crust dates. In the case studies, a MRE correction procedure utilizing stable carbon isotope values to signal the marine content of the crust is reviewed and then used to correct these dates.

A salient issue of typology and chronology studies is the identification of the continuity and discontinuity of archaeological cultures, or rather the traditions and influences associated with and maintained by societies. In eastern Fennoscandia, two cases of rapid and widespread migrations now seem to be confirmed by aDNA-studies: those connected with the dispersion of Typical Comb Ware and Corded Ware. On the other hand, the slower dispersion rates and changes seen in other artefact cultures may have been caused by shared societal networks diffusing commodities at a slower pace. It is possible to study these types of cultural continuities, discontinuities, and contemporaneous trends with the help of Bayesian modelling of ceramic type phases.

In this work, I have identified the following points of time that can be interpreted as times of disruption or disconnection: 1) the termination of pottery production in the northern parts of eastern Fennoscandia at the end of the Early Neolithic, 2) the end of Sperrings 2 Ware in the Early Neolithic, 3) the end of Jäkärlä Ware in southwestern Finland, 4) the end of Early Asbestos Ware in eastern Finland, 5) the arrival of Typical Comb Ware, and 6) the arrival of Corded Ware.

On the basis of typological similarity and strong overlaps in the Bayesian models, it is also possible to identify points of continuity: 1) the continuity between Sperrings 1 and Sperrings 2 Wares; 2) the continuity between Typical and Late Comb Ware; and 3 & 4) the continuity after the Middle and Late Neolithic, after the time of Late Comb Ware and after Corded Ware.

One of the main assets of Bayesian modelling is its flexibility, allowing models to be updated according to the accumulation of new data. Potential

outliers within the corpus of radiocarbon dates can also be detected when larger amounts of data become available.

PREFACE

My work with this dissertation began in the end of the 2000's (2009-2013) with the Argeopop project, led by Professor Päivi Onkamo of the University of Helsinki, Department of Biosciences, with the cooperation of Professor Mika Lavento of the University of Helsinki, Department of Cultures / Archaeology. During the course of this project the database of prehistoric artefacts was started, and at the same time the construction of a database of archaeological radiocarbon dates was launched. Previously, there had been no comprehensive database of this kind, only the lists of radiocarbon dates from single laboratories. In Finland, these date lists were maintained by the Dating Laboratory, University of Helsinki (later Laboratory of Chronology, University of Helsinki).

The radiocarbon database of the Argeopop-project soon came to include radiocarbon dates from other laboratories as well, and – because of my personal interest and initiative – also charred crust and birch bark tar dates from neighbouring countries. The archaeological radiocarbon database thus became the primary study assemblage and tool for dating the ceramic periods in eastern Fennoscandian prehistory. Later on, after the activities of Argeopop-project, I was able to continue my studies with archaeological materials and radiocarbon dates in the Graduate School of Archaeology of the University of Helsinki (2010–2011), and finally, ten years later, within the Kipot ja Kielet ("Beakers and Speakers") –project lead again by Päivi Onkamo, Department of Biology, University of Turku (2018–2020). During this latter project, I was able to finish this dissertation. These projects were closely related to their "sister-projects" Bedlan (led by Outi Vesakoski), Sugrige (led by Päivi Onkamo), and Urko (led by Outi Vesakoski).

Numerous people have helped me over the years, in the projects, in my daytime work at the National Board of Antiquities (now the Finnish Heritage Agency), in my free time, and at home. I really cannot name them all. I reckon, in some way, almost all Finnish archaeologists and archaeological institutions have contributed to my work by excavating, collecting, and taking samples from their archaeological sites. So, I will keep this simple, and must regret my bad memory if someone feels he/she has been left out of my list of individuals to thank.

First, I acknowledge the spirit of the December 2019 Kevo Writing Camp, and its organizer Outi Vesakoski, for setting my mind in the right mood, "tomato-queen" Mervi de Heer for setting the strict timetable, Ulla Moilanen for establishing a competitive spirit (5 pages today! One paper submitted this evening!) and all the other participants for the discussions, lunches, and sauna company. This camp really kicked me in the ass ... and was the true starting point for this dissertation (by the way, I wrote 50 pages in the four days of the camp; papers I-V cited here were already finalized by that time).

So many people have worked and contributed in and around the projects (Argeopop, Kipot ja Kielet, Bedlan, Urko and Sugrige) over the years, that I just cannot remember them all. But thank you all. In a random order, thanks go to at least to Päivi Onkamo, Mika Lavento, Petri Halinen, Markku Oinonen, Outi Vesakoski, Terhi Honkola, Ulla Moilanen, Jarkko Saipio, Tarja Sundell, Elena Molchanova, Juhana Kammonen, Sanni Översti, Jasse Tiilikkala, Elisa Väisänen, Saara-Veera Härmä, Sirpa Leskinen, Enni Lappela, Jenni Santaharju, Elina Salmela, Kerkko Nordqvist, Kerttu Majander, Jaana Oikkonen, Miina Norvik, Minerva Piha, Richard Kowalik, Kristiina Tambets, Mervi de Heer, Rogier Blokland, Michael Dunn, Michael Rießler, Timo Rantanen, Meeli Roose, Anne-Mai Ilumäe, Luke Maurits, Kirsty Maurits, Sanni Peltola, Kati Salo, and Aripekka Junno.

The research environments at the University of Helsinki, and to some extent also at the University of Turku, offered me support during those years, although I have never been an especially active member in e.g. seminars and such. I recognize here my fellow archaeologists, many of whom are also counted as friends. Thank you, Mika Lavento, Visa Immonen, Henrik Asplund, Jussi-Pekka Taavitsainen, Maija Mäki, Kristiina Mannermaa, Miikka Tallavaara, Noora Taipale, Laija Simponen-Robins, Esa Hertell, Mikael A. Manninen, Sanna Saunaluoma, Teemu Mökkönen, Kerkko Nordqvist, Mikael Nyholm, Tapani Rostedt, Marja Ahola, Mikko Suha, Santeri Vanhanen, Johanna Enqvist, Tuija Kirkinen, Petteri Pietiläinen, and Jukka Palm.

The Finnish Heritage Agency has been another "archaeological home" for me for decades. So many people there have contributed to my view on eastern Fennoscandian prehistory. To mention only a few, thank you Helena Taskinen, Torsten Edgren, Matti Huurre, Pirjo Uino, Marianne Schauman-Lönnqvist, Tuula Heikkurinen-Montell, Leena Söyrinki-Harmo, Taisto Karjalainen, Miikka Haimila, Minna Ryyppö, Jutta Kuitunen, Leena Ruonavaara, Päivi Pykälä-aho, Hanna Kääriäinen, Oili Räihälä, Kreetta Lesell, Helena Ranta, Päivi Kankkunen, Simo Vanhatalo, Kaarlo Katiskoski, Vesa Laulumaa, Ville Rohiola, Esa Mikkola, Katja Vuoristo, Johanna Seppä, Marianna Niukkanen, Inga Nieminen, Tanja Tenhunen, John Lagerstedt, Jan-Erik Nyman, Sara Långsjö, Tuija Väisänen, Heli Lehto, Riikka Alvik, Minna Koivikko, and Olli Eranti. The list is long, but incomplete!

The individual papers that this dissertation is based on would not have been born without many collaborators. So, I thank you Markku Oinonen, Päivi Onkamo, Volker Heyd, Miikka Tallavaara, Elisabeth Holmqvist-Sipilä, Åsa M. Larsson, Christian Carpelan, Teija Alenius, Tuire Nygrén, Sanna Kivimäki, and Tarja Sundell.

Originally, my work was supervised by Tuija Rankama and Markku Oinonen, but later Mika Lavento took the burden from Tuija. During the

spring of 2020, I asked my friend and colleague Satu Koivisto to read the text so far. She took up the task meticulously, and I am glad to name her as my *grand vizier* supervisor! Thank you all! My pre-examiners Henny Piezonka and Aivar Kriiska are thanked for sharing their research over the years, and also for their kind comments on my work. Christopher TenWolde is thanked for his very fine work with the language revision of the dissertation.

When I started my PhD work in the middle of the 1990's, the original goal was much different than the outcome is today. In spite of that, I am grateful for the grants I received from various foundations in the early years of my research: Karjalaisen Kulttuurin Edistämissäätiö, Otto A. Malm Foundation, Emil Aaltonen Foundation, Finnish Cultural Foundation, Oskar Öflund Foundation, E.J. Sariola Foundation, and Niilo Helander Foundation.

Life has flown by during the years of my archaeological career, and many people have become a part of my life. I thank you all for your support, love and friendship: Taru Vena, Miikka Pesonen, Annamari Levanto, Erika Smeds, Emmi Rikman, and Sirpa Leskinen. And Taisia, my daughter, you are always in my heart.

Helsinki, in the hazy shade of winter, 6.1.2021.

Petro Pesonen

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original publications, which are referred to in the text by their Roman numerals:

I Oinonen, M., Pesonen, P. & Tallavaara, M. 2010. Archaeological radiocarbon dates for studying the population history in eastern Fennoscandia. Proceedings of the 20th International Radiocarbon Conference, edited by Jull, A.J.T. *Radiocarbon*, Vol 52, Nr 2–3, 2010: 393–407. – Author's contributions: All authors initiated and designed the study. PP and MO provided the data. MO analysed the data and wrote the paper with contributions from PP and MT. All authors provided editorial comments and approved the final manuscript.

II Pesonen, P., Oinonen, M., Carpelan, C. & Onkamo, P. 2012. Early Subneolithic ceramic sequences in eastern Fennoscandia – a Bayesian approach. Proceedings of the 6th International Radiocarbon and Archaeology Symposium, edited by Boaretto, E. and Rebollo Franco, N.R. *Radiocarbon*, Vol 54, Nr 3–4, 2012: 661–676. – Author's contributions: PP initiated the study, and all authors designed it. MO and PP gathered the radiocarbon data. PP and MO analysed the data and wrote the paper with contributions from PO and CC. All authors provided editorial comments and approved the final manuscript.

III Oinonen, M., Pesonen, P., Alenius, T., Heyd, V., Holmqvist-Saukkonen, E., Kivimäki, S., Nygrén, T., Sundell, T. & Onkamo, P. 2014. Event reconstruction through Bayesian chronology: Massive mid-Holocene lakeburst triggered large-scale ecological and cultural change. *The Holocene* 2014, Vol. 24(11): 1419–1427. – Author's contributions: PP, MO and PO initiated the study, and all authors designed it. MO and PP gathered the radiocarbon data, PP gathered the archaeological and osteological data. EHS analysed the pottery, PP and MO analysed the other data and wrote the paper with contributions from all authors. All authors provided editorial comments and approved the final manuscript.

IV Pesonen, P. & Oinonen, M. 2019. The chronology of Jäkärlä Ware – Bayesian interpretation of the old and new radiocarbon dates from Early and Middle Neolithic southwest Finland. *Documenta Praehistorica* XLVI (2019): 246–267. – Author's contributions: PP initiated and designed the study and gathered the data. PP also analysed the data and wrote the paper with contributions from MO.

Both authors provided editorial comments and approved the final manuscript.

V Pesonen, P., Larsson, Å.M. & Holmqvist, E. 2019. The chronology of Corded Ware culture in Finland – reviewing new data. Fennoscandia archaeologica XXXVI (2019): 130–141. – Author's contributions: PP initiated the study, and all authors designed it. PP gathered and analysed the radiocarbon data and wrote the paper with contributions from all authors. All authors provided editorial comments and approved the final manuscript.

1 INTRODUCTION

1.1 NEOLITHIC CHRONOLOGICAL STUDIES IN EASTERN FENNOSCANDIA

Chronology is the key to reconstructing and understanding our evidence for past life, which must remain only descriptive if the chronological order of events is not known. In studies of the Stone Age of eastern Fennoscandia, the importance of chronology has been realized since the beginnings of antiquarian research. The recognition for this goes to the pioneer archaeologists of this field, who worked in close cooperation with natural scientists. They were able to construct reliable chronologies by understanding the natural processes still visible in the archaeological material, especially in the locations of settlement sites.

Before the radiocarbon method came into use in the 1960's, the usual method for dating Stone Age sites in eastern Fennoscandia was the use of stratigraphic shoreline chronology. The latter has been effective not only in the coastal regions of the Baltic Sea, the Arctic Ocean, and the White Sea, but also for the larger inland lakes such as Lake Ladoga, Lake Onega, Lake Päijänne, and Lake Saimaa. The method is based on measuring the postglacial rebound of the earth's crust, which has resulted in regressive water levels. As a result, older hunter-gatherer sites are today situated at higher elevations above the current sea level than more recent ones, and thus sites can be dated in relation to each other. This phenomenon was first used on a large scale by early scientists Julius Ailio (1915) and Aarne (Europaeus)-Äyräpää (e.g. Europaeus 1922; 1926; Europaeus-Äyräpää 1930; Äyräpää 1956). The latter classified Finnish coastal Stone Age ceramics according to the elevation of the sites where they were found and the typology of the ceramics at these sites, largely affirming the phases that were established earlier (Ailio 1909; Pälsi 1915).

In the lake basins, the hydrological pattern is not always as simple as that. Depending on the location of the drainage channels, parts of the previous coasts of lakes - as well as the settlement sites on their shores - may actually have been inundated, thus resulting in a reversed shoreline chronology. Nevertheless, shoreline changes in the big lakes have been successfully used in constructing the Stone Age chronology as well (e.g. Siiriäinen 1970; 1974; Saarnisto & Siiriäinen 1970; Matiskainen 1979; Saarnisto 1970; Arponen & Hintikainen 1992; Jussila 1999; Paper III).

The main typo-chronological divisions created by Äyräpää are still in use, although he was of the opinion that the whole comb ceramic sequence represented one continuum, traceable at least in the main distribution area of comb ceramic styles. Later studies (e.g. Räihälä 1996; Leskinen 2003; Pesonen 2004; Nordqvist & Mökkönen 2015) have both challenged this view and suggested several refinements on the typology. The absolute dates for the cultures and ceramic periods were determined later, when the radiocarbon method came into use (e.g. Meinander 1971). The shoreline chronological method was also refined and correlated with radiocarbon dates beginning in the late 1960's and early 1970's, first and foremost in the coastal Baltic Sea area by Ari Siiriäinen (e.g. 1974; 1978), but also by others (Nuñez 1978; Salomaa & Matiskainen 1985). To a certain extent, the shoreline chronology of the Arctic Ocean has been radiocarbon correlated over the last decades (e.g. Helskog 1980; 1984; Olsen 1994; Romundset et al. 2011). Nowadays, local shoreline chronologies are fixed with relevant radiocarbon dates.

In this dissertation, the chronology of some of the Stone Age ceramic styles is taken under consideration once more. Some surprisingly old ages for early ceramics from marginal areas of their distribution areas challenge traditional models of innovation centres and diffusion routes (e.g. Hallgren 2004; 2008; 2009; Skandfer 2005; 2009; 2011). While the number of new and reliable radiocarbon dates are still too few to establish a comprehensive representation of the sequence of all typological events, the old dates can still provide more information when approached from the perspective of the new knowledge gained on radiocarbon dating error sources and other developments. In addition, some new samples related to these ceramic groups have been dated and are presented in this dissertation. The analysis of the radiocarbon dates was done via Bayesian modelling in a quantitatively comparable way, which allows for the chronological models to be updated according to new data.

Geographically the study covers the area of eastern Fennoscandia, which is a term used for Finland, part of the Norwegian coast on the Arctic Ocean east of the Tana Fiord and River, and western parts of Russia: Murmansk Oblast, the Karelian Republic, and parts of Leningrad Oblast (Fig. 1.1).[1] In many cases, the most comprehensive radiocarbon data is from Finland. The Russian material is mostly drawn from the works by Kerkko Nordqvist and Teemu Mökkönen (e.g. Nordqvist 2018), but the most important Russian contributions are also mentioned. Northern Norway is represented only in the Early Neolithic material – there are no other Neolithic ceramics that have been identified from the area. The distribution of some of the ceramic types is not restricted to eastern Fennoscandia; they are also present in Sweden, the Baltic States, and Belorussia.

The chronological range of the dissertation covers the Early, Middle, and Late Neolithic Stone Ages, as defined for Finland, and dated to ca. 5200-2300 calBC (Fig. 1.2; Nordqvist & Mökkönen 2017: Fig. 1). In northwestern Russia, this same period of time also covers the main part of Eneolithic, starting there

[1] The northwestern "arm" of Finland, the Enontekiö area, does not actually geographically belong to eastern Fennoscandia, but to western Fennoscandia. However, for the sake of simplicity, this area is dealt with here as belonging to eastern Fennoscandia.

from ca. 3400 calBC after the Late Neolithic (Nordqvist & Mökkönen 2017: Fig. 1). In Norwegian chronology, Phase III of the Mesolithic ends ca. 4900 calBC, slightly later than the beginning of the Early Neolithic in Finland (e.g. Manninen 2014: 5). However, only the Early Neolithic Säräisniemi 1 pottery (or Early Northern Comb Ware in Norwegian terminology; Skandfer 2009) was used during the period discussed in this dissertation (Skandfer 2009: Fig. 12.4).

Figure 1.1. The geographical area covered in the dissertation. Eastern Fennoscandia is indicated with grey shading. Note the Enontekiö area, "the northwestern arm of Finland", in northwest Lapland.

The term "Neolithic" originally in John Lubbock's late 19th century perception was based on new Stone Age artefact categories, like pottery and polished stone tools, in separation of the old Stone Age tools. Neolithic package, as we understand it now, emerged first in Gordon Childe's 1920's theory of Neolithic revolution (Childe 1925), which involved, apart from the above mentioned pottery and polished stone tools, essentially food production but also village communities and social practices involved there (e.g. Verhoeven 2011). Neolithic package and Neolithic revolution fits well to describe the development of farming communities in Anatolia and beyond, and as later learned, also was a package carried with moving communities westward and northward (e.g. Bramanti et al. 2009; Haak et al. 2010; Gamba et al. 2011; Lazaridis et al. 2014; Rivollat et al. 2015).

However, this southern concept of neolithisation has never suited well to the northern Europe, where all these "Neolithic" features were presented during a long period of time and in extremely slow pace (e.g. Nordqvist 2018: 81). Polished stone tools appeared already during the Mesolithic (e.g. Matiskainen 1989), pottery was introduced in northwest Russia in the first half of the 7th millennium calBC (Mazurkevich & Dolbunova 2015; Piezonka 2015), pithouses appearead alongside or earlier than pottery (Zhulnikov 2003; Mökkönen 2011a), large village systems were constructed in the coastal areas from 5th century calBC (Pesonen 1999 b; Vaneeckhout 2009) and animal husbandry arrived in the area only with the Corded Ware culture from 2900 calBC onwards (Cramp et al. 2014; Pääkkönen et al. 2019). Actual cultivation was not practiced in the eastern Fennoscandia in some places until the Medieval period (Lahtinen et al. 2017 and references therein), though single cerealia pollen exists already in the Early and Middle Neolithic (Alenius et al. 2013; 2017). This situation in the northern forests after Mesolithic has led archaeologists to call this pottery-bearing period for example as Sub-Neolithic (e.g. Paper II), Para-Neolithic, Proto-Neolithic, Alternative Neolithic, Forest-Neolithic or even Pottery-Mesolithic (e.g. Meinander 1961; Gimbutas 1956; Nowak 2017; for further discussion see Nordqvist 2018).

In this dissertation, term "Neolithic" is used in its northeastern definition to describe the pottery producing period between Mesolithic and Bronze Age.

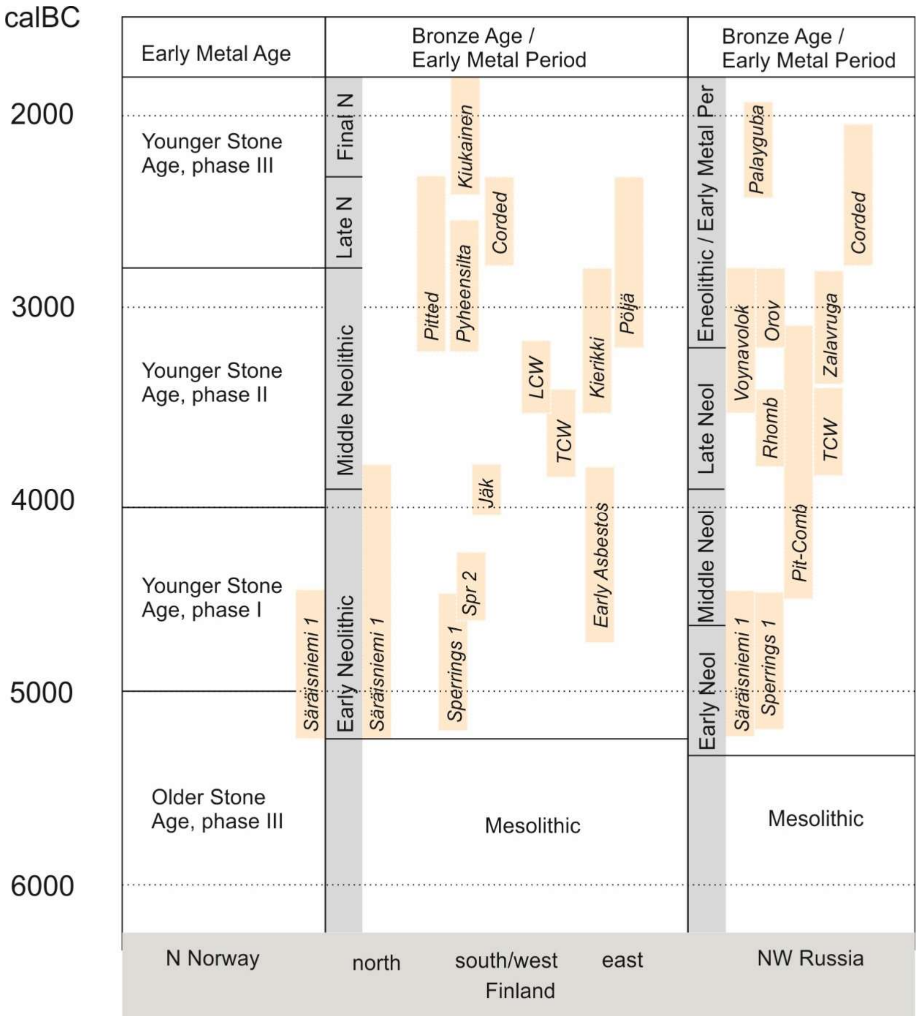

Figure 1.2. Periodisation and schematic timeframes for Neolithic ceramics in eastern Fennoscandia, for each sub-area. Periodisation in Norway according to Hesjedal et al. 2009, in Russia according to Tarasov et al. 2017, and in Finland according to Nordqvist & Mökkönen 2017. Spr 2 = Sperrings 2 Ware, Jäk = Jäkärlä Ware, TCW = Typical Comb Ware, LCW = Late Comb Ware, Orov = Orovnavolok Ware, Rhomb = Rhomb-Pit Ware.

1.2 OBJECTIVES AND SCOPE

Radiocarbon dating has enabled the construction of the chronological backbone of the Stone Age worldwide, and this also applies to the Neolithic of eastern Fennoscandia. Relative approaches, such as typological methods and shoreline chronology, have illustrated the typological and chronological relation of artefact types and/or cultures with each other, but determining absolute chronology was only possible after the radiocarbon revolution.

However, despite 50 years of radiocarbon dating, some parts of eastern Fennoscandian prehistory have yet to be updated because of the lack of relevant radiocarbon dates. There are also gaps in the chronology.

Before burnt bone could be radiocarbon dated (see Lanting et al. 2001), only charcoal and rare wooden artefacts could produce radiocarbon dates from the Mesolithic. The situation was much same with the Neolithic periods as well, until the Accelerator Mass Spectrometry (AMS) technique came into use for radiocarbon dating. One can say that burnt bone finally provided dates for the Mesolithic of eastern Fennoscandia. This also applies to some extent to the Neolithic, where charred crust and birch bark tar were not available for radiocarbon dating, or only rarely so, for some periods.

In the case of the Neolithic, and before my dissertation project, only a limited supply of relevant radiocarbon dates were available for the Early Neolithic Jäkärlä and Early Asbestos Wares, Middle Neolithic Pyheensilta Ware, and Late Neolithic Corded Ware. The uneven division of the radiocarbon dates had made it difficult to create coherent and comparable chronologies. During my work, my co-authors and I were able to improve this situation for three of these ceramic groups (Early Asbestos Ware, Jäkärlä Ware, and Corded Ware: Papers III-V). Pyheensilta Ware still remains a phase without an adequate number of relevant radiocarbon dates (e.g. Nordqvist 2018).

Another characteristic of the research history has been an assumption that ceramic types form a continuum from one type to the next, and that the same applies to narratives of settlement history in general: in this light, it appeared to be a slow and steady continuity. Bayesian chronological models provide the quantitative means to assess the validity of this assumption by producing estimates for the boundaries (beginnings, endings) of ceramic phases. In this work, my purpose has been to establish a quantitative framework for ceramic phases and their phase boundaries while considering the statistical, and even systemic, uncertainties within the radiocarbon dating method by using Bayesian inference. Quantitative analysis allows for the identification of possible gaps between the appearances of ceramic types, and thus provides the possibility of discussing their continuity – or discontinuity.

My main research goals, as addressed in the papers I-V, are as follows:

1) <u>Assessing the most valid radiocarbon dating materials in the study of the chronology of the Early, Middle, and Late Neolithic ceramics of eastern Fennoscandia, and identifying the error sources in the process</u>. This is the backbone of any research based on radiocarbon dates. Paper I was published already in 2010, but it still holds valid information on the contents of the radiocarbon dates database for Finland and eastern Fennoscandia, and it is the most important paper for answering the questions related to this topic, e.g. discussing the own age effects of the samples. Other error sources, especially

the marine reservoir effect (MRE), were also addressed in Papers II, IV, and V.

2) Developing a method for marine reservoir effect (MRE) correction. Reservoir effects severely hamper the use of some materials to establish chronologies, emphasizing the need to understand the nature and origins of the materials used to provide dates. Paper II explored the potential error source deriving from marine reservoirs, which especially affect charred crust dates, and which in turn form a crucial portion of the radiocarbon dates used for the direct dating of ceramics. In addition, a method to correct this marine reservoir effect for the radiocarbon dates from eastern Fennoscandia was presented here for the first time. The reservoir effect correction calculations were further developed in Paper IV.

3) Refining the chronology of the Early, Middle, and Late Neolithic ceramics in eastern Fennoscandia. The chronological sequencing of ceramic phases with a Bayesian chronological calibration tool (Oxcal) was begun in Paper II, in which the Säräisniemi 1, Sperrings 1, and Sperrings 2 ceramics chronologies were evaluated. Paper III, in turn, concentrated on the dating of a particular event, the Vuoksi breakthrough, but also included Bayesian modelling of Early Asbestos Ware and Typical Comb Ware. In Paper IV, the reservoir effect correction was revised, and several Early and Middle Neolithic ceramic types prevalent in southwestern Finland were modelled: Jäkärlä Ware, Sperrings 1 Ware, Sperrings 2 Ware, Typical Comb Ware, and Late Comb Ware. The final Paper V dealt solely with Late Neolithic Corded Ware and its chronological position in the prehistory of eastern Fennoscandia.

The overarching theme of this dissertation arose from these goals: continuity and discontinuity in the Neolithic pottery traditions in eastern Fennoscandia, and how this is reflected in the light of Bayesian models performed with radiocarbon dates. This theme was also somewhat touched upon previously, especially in Papers II-IV; the overall picture is illustrated in the discussion chapter (Chapter 6), as depicted below (Fig. 1.3).

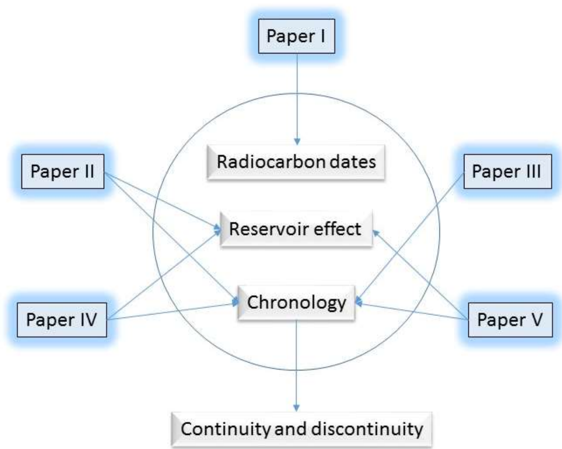

Figure 1.3. Schematic representation of the interconnectedness of the themes in the discussion, and their role in Papers I-V.

2 BACKGROUND: NEOLITHIC POTTERY IN EASTERN FENNOSCANDIA

2.1 THE FEATURES OF NEOLITHIC CERAMICS IN EASTERN FENNOSCANDIA

In this dissertation, I have applied the periodisation of the Neolithic in Finland as recently revised by Nordqvist & Mökkönen (2017). In this periodisation, the Neolithic has been divided into four phases: Early Neolithic (ca 5300–3900 calBC), Middle Neolithic (ca 3900–2800 calBC), Late Neolithic (ca 2800–2300 calBC), and Final Neolithic (ca 2300–1800 calBC). Obviously, the exact timeframes of the periods hold only so long as the chronologies of typological phases defining the boundaries remain same. The periodisation is somewhat southern-Finland oriented. Nevertheless, as Nordqvist & Mökkönen (2017: 80) note, there is still enough supporting evidence from other parts of the country to use this system, at least tentatively. This system is therefore accepted in this dissertation, although some of the chronological boundaries should be tuned according to the new dates that have been defined during this work.

The use of pottery was adopted in the Late Mesolithic environment in eastern Fennoscandia, with no prototypes witnessing any so-called learning phases of pottery production. The routes for the introduction of pottery into these northern areas was apparently two-fold: early Sperrings 1 ceramics in Karelia probably had its roots in the Upper Volga region, and Säräisniemi 1 Ware stemmed from the "northern type" of Comb Ceramics developed in the Sukhona and Upper Volga regions (Piezonka 2015: 284). It is possible that the first appearances of pottery were only fragments and pieces of pots, not even actual vessels (Nordqvist 2018: 94-95), and it has been argued that the significance of the early pottery in fact cannot be considered only in purely practical terms but was understood as a symbol of remoulding the earth itself (Herva et al. 2014: 147; 2017). However, pottery eventually came to have practical uses as containers and food-preparation vessels, alongside containers made of organic materials (e.g. Siiriäinen 1981; Edgren 1982; Nuñez 1990; Oshibkina 1996; Pesonen & Leskinen 2009; German 2009).

From a systematic point of view, the names of the ceramic groups, such as Early Comb Ware, Typical Comb Ware, Early Asbestos Ware, or – in Russia – Pit-Comb Ware, Comb-Pit Ware, and Rhomb-Pit Ware, are problematic. The designation "Comb Ware" binds traits of potentially different origins into the same continuum, and the same applies to "Asbestos Ware", with the presupposition that if a pot is tempered with something other than asbestos it is to be excluded from the group. Eponymic terms, such as Sperrings Ware and Kaunissaari Ware, would be much less vulnerable to the technological peculiarities of different environments and areas (see e.g. Pesonen 2004). Avoiding over-arching umbrella terms would help us to see the groups as independent and discontinuous (unless otherwise proved) traditions.[2]

One further example of a difficult choice of terminology is the case of Säräisniemi 1 Ware, which in the Norwegian context has received a new, even more confusing name, "Early Northern Comb Ware" (Skandfer 2005; 2009), which includes three different exclusive terms: "early", "northern", and "comb". The complications in typologies and terminologies in eastern Fennoscandian pottery are further discussed by Nordqvist (2018: 62–67). There is obviously a need for a better terminology with fewer restrictions – I find the eponymic terms most suitable and flexible in describing Neolithic pottery. Alas, no proper terminology is at hand for most of the groups, and the endeavour of establishing one must wait for further holistic treatments of the eastern Fennoscandian Neolithic.

2.2 EARLY AND MIDDLE NEOLITHIC POTTERY TYPES IN EASTERN FENNOSCANDIA

2.2.1 EARLY NEOLITHIC (CA 5300–3900 CALBC)

Eastern Fennoscandian Early Neolithic ceramics are comprised of the following main typo-chronological groups: Säräisniemi 1 Ware, Sperrings 1 and 2 Wares, Pit-Comb Ware, Jäkärlä Ware, and Early Asbestos Ware (including asbestos tempered variant of Sperrings 2 Ware and Kaunissaari Ware). There are some traits that are common to most of these pottery styles: 1) ovaloid pottery forms with round or spit bottoms, 2) horizontal decoration, 3) only a few decorative elements are used for each vessel, 4) the vessels were manufactured with the coil-technique, and 5) small cups are present in most styles.

Säräisniemi 1 Ware is found in the northern and middle parts of eastern Fennoscandia (Fig. 2.1; 2.2). In Norway, there are some sites with this ware on the coast of the Varanger fjord, and more in the upper Pasvik River valley (e.g. Skandfer 2009). In Finland, Säräisniemi 1 Ware has been found mainly in the northern parts of the country: Lapland, Kainuu, and Northern Ostrobothnia (Torvinen 2000), and in Russia the distribution covers most of Murmansk Oblast and the northern parts of the Republic of Karelia (Nordqvist 2018: Fig. 26; German 2009: Fig. 8.1). Säräisniemi 1 Ware was originally identified in the

[2] An interesting discussion on northern Finnish organic tempered (Typical) Comb Ware as contrasted with Zalavruga Ware in the White Sea region clearly illustrates the problems inherent in vast umbrella-terms, which can easily drown out the variation within different pottery traditions (Nordqvist & Mökkönen 2015; also Nordqvist 2018).

finds from the Nimisjärvi region in Säräisniemi (Vaala), northern Finland, in the beginning of the 1900's (Ailio 1909) but was described typologically only later in the 1950's (Simonsen 1957) with comprehensive surveys in Finland (Torvinen 2000), in Norway (Skandfer 2003; 2005; 2011), and in Russia (German 2009).

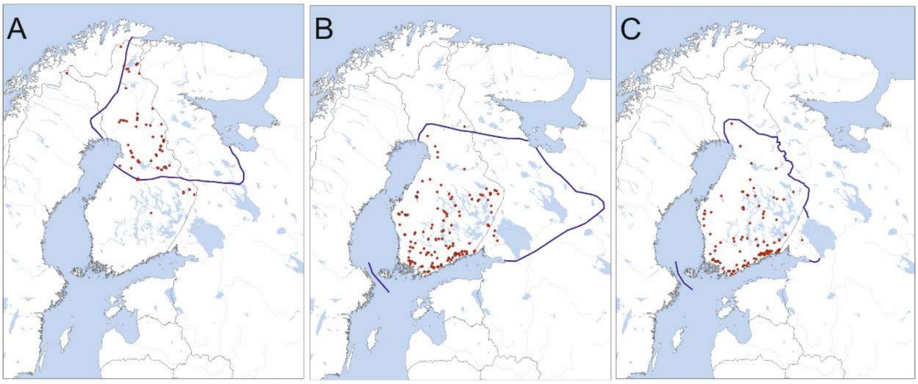

Figure 2.1. The distribution of A) Säräisniemi 1 Ware, B) Sperrings 1 Ware, and C) Sperrings 2 Ware. The general distribution area of Säräisniemi 1 Ware and Sperrings 1 Ware is adopted from Nordqvist 2018: Fig. 26 and Sperrings 2 Ware from Nordqvist & Mökkönen 2017: Map 1. The locations of the find-places in Finland are taken from the Kipot ja Kielet –database, University of Turku (points in database until 12/2019).

The Säräisniemi 1 pots are round- or spit-bottomed open jars, with a volume of up to 10 litres. Small cups are also present in the material. The pots were apparently fired at low temperatures, as at least Karelian Säräisniemi 1 Ware has been reported as being crumbly and badly preserved (German 2009: 266). The decoration covers the whole pot and consists of horizontal decorative zones (Fig. 2.2). Special decorative characteristics include the use of pits, cord-like impressions, and comb-stamps with pits at the end of the stamps (e.g. Torvinen 2000; Skandfer 2009; German 2009; Huurre 1983; Simonsen 1957; Siiriäinen 1971). The rims of the pots are straight, and there is no decoration on top of the rim. Many Säräisniemi 1 vessels have been painted red. The coil-technique has been used to build the pot, and the paste has been tempered with crushed quartz or other stones, or sand, and in some cases also with grog (Skandfer 2009). In Norway, Säräisniemi 1 has been rejected as a term, and Early Northern Comb Ware (ENCW) has been adopted to underline the extensive variation in decoration between sites (Skandfer 2009). However, this term is also problematic, as will be discussed later.

Sperrings 1 Ware (Older Early Comb Ware, Early Comb Ware 1, Ka 1:1) has a more southern distribution than its northern counterpart, Säräisniemi 1 Ware. The northern line of the distribution is drawn approximately between the northern part of the Bothnian Bay and the southern bay of the White Sea. Southwards, Sperrings 1 Ware is found in the Karelian Isthmus and along the southern shores of Lakes Ladoga and Onega (Fig. 2.1; Nordqvist 2018: Fig. 26). The distribution of Sperrings 2 Ware (Younger Early Comb Ware, Early Comb Ware 2, Ka 1:2) is essentially the same as that of Sperrings 1 Ware, with the exception that this pottery has not been much recognised in northwestern Russia (Fig. 2.1; Nordqvist & Mökkönen 2017: 81). The lack of find-spots in this region may very well derive from a different perspective on typology between Finnish and Russian scholars. It is thus possible that Sperrings 1 and 2 Wares have not been individually recognised in the Russian research tradition (Nordqvist 2018: 63). However, an asbestos tempered variant of Sperrings 2 Ware has also been discovered on the Russian side of the border (e.g. Pesonen 1996 a; 1996 b; Paper III).

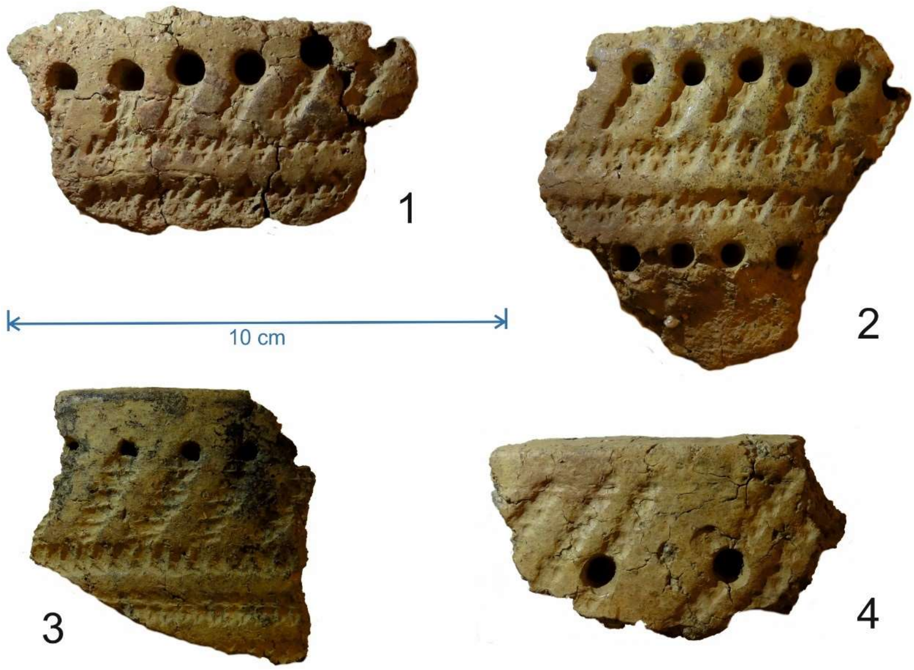

Figure 2.2. Säräisniemi 1 Ware from Finland: 1) KM 11762:3 Utajärvi Pyhänniska, 2) KM 11762:29 Utajärvi Pyhänniska, 3) KM 15393:1105 Hyrynsalmi Vonkka II, and 4) KM 19903:151 Hyrynsalmi Vonkka II. Photo: Petro Pesonen.

Sperrings 1 pottery is generally tempered with crushed quartz or feldspar, but dissolved organic tempers are not so rare, at least in the southern and western parts of Finland. The vessels are usually spit-bottomed large jars, but round-bottomed jars and small cups are also known. The rim is straight and undecorated. The decoration patterns are either horizontal or vertical. The decoration motifs are varied and consist of e.g. small pits (often on top of other decoration), twisted cord stamps, fish vertebrae stamps, drawn lines (e.g. herring-bone patterns), and different kinds of notches etc. (Fig. 2.3; Oshibkina

1996; German 2009; Vitenkova 1996 a; Andreeva & Gusentsova 1996; Europaeus-1930; Äyräpää 1956; Luho 1957).

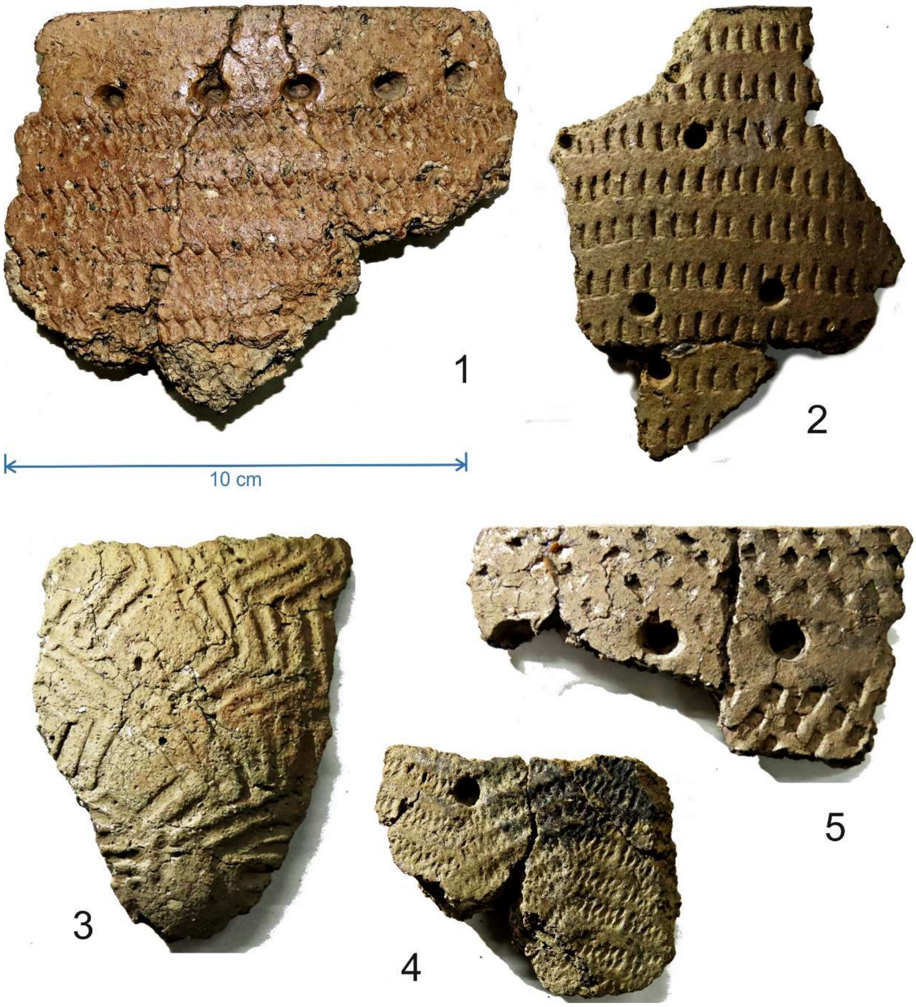

Figure 2.3. Sperrings 1 Ware from Finland and Russia: 1) KM 9420:1 Lapinjärvi, 2) KM 9409:137,139 Sastamala (Kiikoinen) Uusi-Jaara, 3) KM 9100:133 Lapinjärvi Kronhaga, 4) KM 8699:34 Poljany (Uusikirkko) Kelonen, and 5) KM 9106:19 Lapinjärvi Backmansbacken. Photo: Petro Pesonen.

Sperrings 2 pottery decoration is a simpler version of Sperrings 1 decoration: the pits are no longer used and usually the decoration consists only of horizontal zones of comb-stamps. Twisted cord stamps sometimes occur, and there may be some intermittent motifs between the comb-stamp zones. The straight rim top is often decorated with comb-stamps, and the pots are tempered with crushed stone, sand, or organic temper (Fig. 2.5; Europaeus-

Äyräpää 1930; Edgren 1966; Rankama 1982; Äyräpää 1956). According to Aarne Äyräpää (Europaeus-Äyräpää 1930), Sperrings 2 Ware represents a direct continuum from Sperrings 1 Ware. An asbestos tempered variant of Sperrings 2 Ware was used mainly in inland Finland (Saimaa and Päijänne Lake areas, Northern Ostrobothnia; Pesonen 1996 b: 23); it is otherwise generally similar to Sperrings 2 Ware pottery, with the exception of temper. It also has shared decorative features with the asbestos tempered Kaunissaari Ware (Pesonen 1996 a; 1996 b).

Contemporary to Sperrings 2 Ware, Pit-Comb Ware (in Finnish terminology Eastern Pitted Ware) is distributed throughout the eastern part of eastern Fennoscandia: eastern Finland, the southern parts of the Republic of Karelia, and Leningrad, Vologda, and Arkhangelsk Oblasts (Fig. 2.4; Nordqvist & German 2018). The typo-chronological position of Pit-Comb Ware is prior to the beginning of Typical Comb Ware and Rhomb-Pit Ware, and its roots have been considered to be north of the Lyalovo Culture sphere in the Volga-Oka area, but also south-east of Lake Onega (Nordqvist & German 2018; Lobanova 1991; 2004). The dominant feature in the appearance of Pit-Comb Ware pottery is the use of pits as decoration. The fields and rows of pits are alternating with rows of stick stamps, sometimes also comb-stamps (Fig. 2.5). The rim top is usually thickened and decorated, but other types of rim designs appear as well. Large jars and small vessels exist. The temper is usually coarse sand (Nordqvist & German 2018). The later stages of Pit-Comb Ware saw more diverse decoration and forms in pottery (Vasilyeva & Akulov 2018).

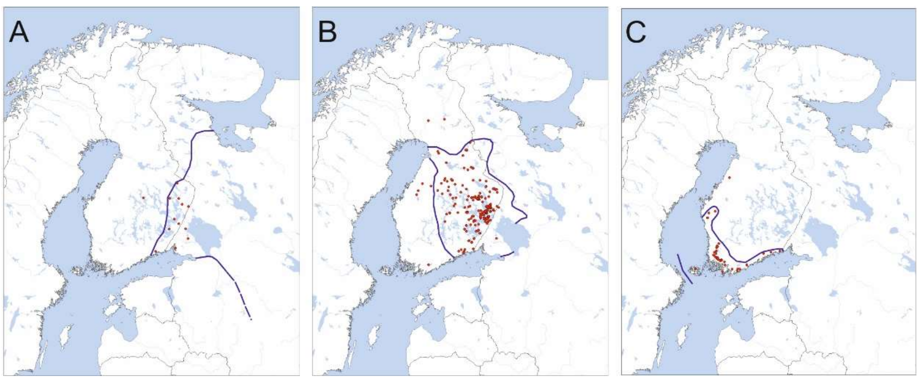

Figure 2.4. The approximate distribution of A) Pit-Comb Ware, where the western limit of the general distribution area is adopted from Nordqvist & German 2018; B) Early Asbestos Ware, where the general distribution area is adopted from Nordqvist & Mökkönen 2017: Map 1; C) Jäkärlä Ware, where the general distribution area is adopted from Nordqvist & Mökkönen 2017: Map 1. For Finland and ceded Karelia (formerly part of Finland), the points of the find-places in maps A and B are taken from the Kipot ja Kielet –database, University of Turku (points in database until 12/2019) and in map C the points of the find-places are taken from Paper IV.

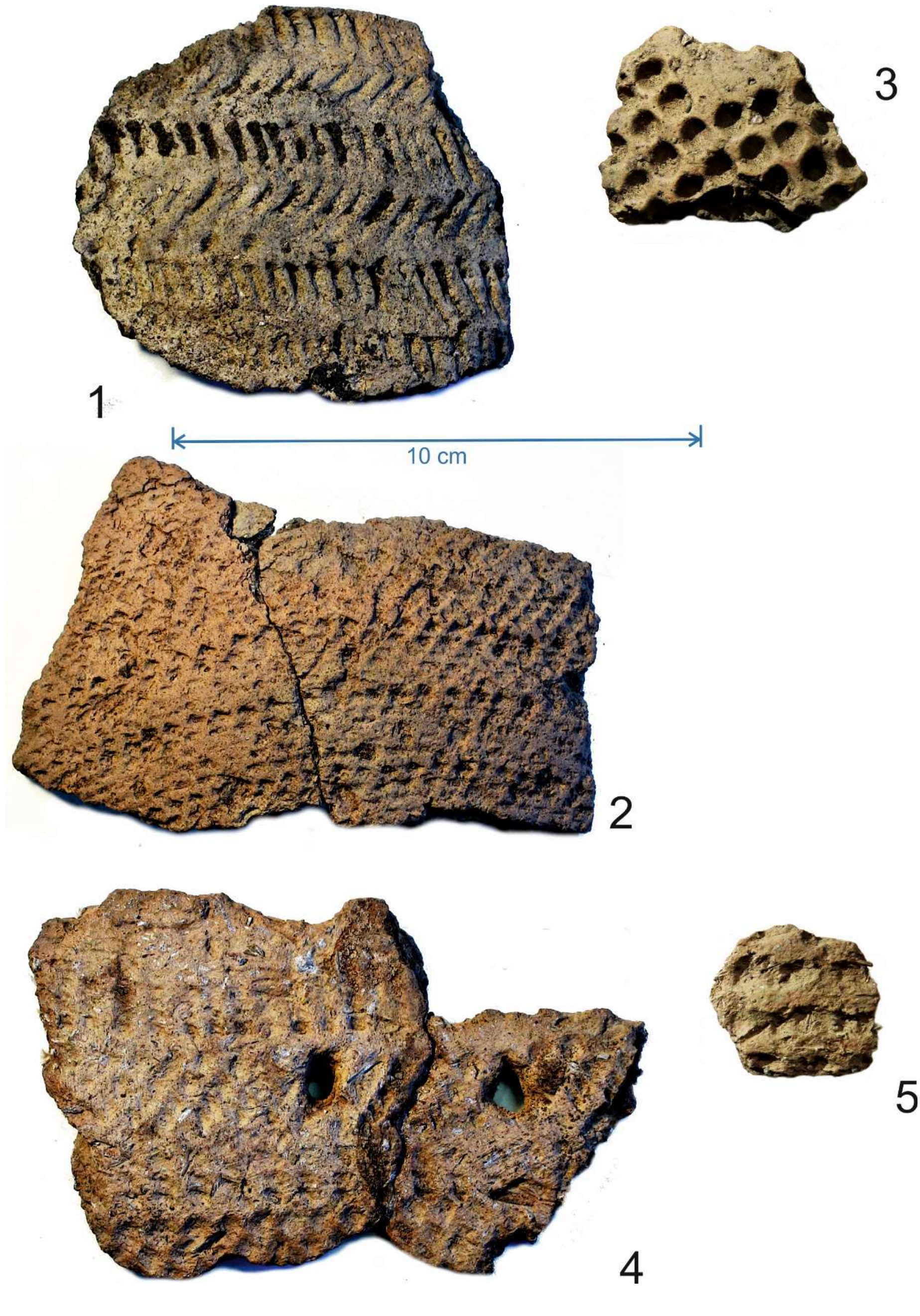

Figure 2.5. Early Neolithic ceramics from Finland and Russia. 1) Sperrings 2 Ware, KM 31107:399 Espoo Kläppkärr (Hela-3173: 5439±43 BP); 2) Sperrings 2 Ware, KM 18900:577 Loviisa (Liljendal) Kvarnbacken; 3) Pit-Comb Ware, KM 8784:3 Kurkijoki Räkköläinen; 4) Early Asbestos Ware, KM 18795:5 Kiuruvesi Hukkala (Hela-3174: 5273±43 BP); 5) Early Asbestos Ware, KM 8047:6 Sevastjanovo (Kaukola) Kyöstälänharju. Photo: Petro Pesonen.

Tempering with asbestos minerals was invented in the mid-5th millennium calBC in the region of northern Lake Saimaa, where the natural asbestos deposits were easily available to potters manufacturing Sperrings 2 Ware (e.g. Pesonen 1996 a; 1996 b; 2001; Paper III; Lavento & Hornytzkyj 1996; Gerasimov et al. 2019). The basic study of the early asbestos tempered pottery resulted in the definition of two types of Early Asbestos Ware: Asbestos tempered Sperrings 2 Ware and Kaunissaari Ware (Pesonen 1996 a; 1996 b). The difficulties still emerging in the separation of these two variants, which in addition are present largely in the same geographical areas in eastern Finland, has led to the use of the umbrella-term Early Asbestos Ware, which obviously cannot be used without caution (Fig. 2.4; see Nordqvist 2018: 63). Both of the variants have very dense, horizontal decoration, and the rim top is also usually decorated. The rims are usually thickened, and with asbestos tempered Sperrings 2 Ware rim-list examples also appear (like "conventional" Sperrings 2 Ware). In Kaunissaari Ware, the vessel walls are sometimes profiled, giving an impression of bowl-like vessels. The main decorative overall feature separating asbestos tempered Sperrings 2 Ware and Kaunissaari Ware is the use of long (and narrow) comb- (and other) stamps in Sperrings 2 Ware compared to Kaunissaari Ware, where the stamps are frequently very broad and oval-shaped, occasionally made with bone-ends (Fig. 2.5; Pesonen 1996 a; 1996 b; 2001).

Jäkärlä Ware is a characteristically southwestern Finnish ceramic group. So far, it has been discovered only in the present area of Finland (Fig. 2.4; Edgren 1966; Paper IV). Its decoration, made with oval stamps, has led to the suggestion of its contemporaneity with Kaunissaari Ware (see Pesonen 1996 b: 31), but without reliable radiocarbon dating this assumption has not been easy to assess. Jäkärlä Ware is usually organic tempered, but sand temper also occurs rarely. A few flat-bottomed vessels have also been identified in Jäkärlä Ware, along with small cups (Edgren 1966; 1982). The decoration consists mainly of broad oval stamps, and pits have not been used at all (Fig. 2.6; like Early Asbestos Ware). The rim top has only rarely been decorated. Sometimes the top rim-edge has been bent slightly inwards, to give the vessel a closed form (Edgren 1966; 1982; Asplund 1995; Paper IV).

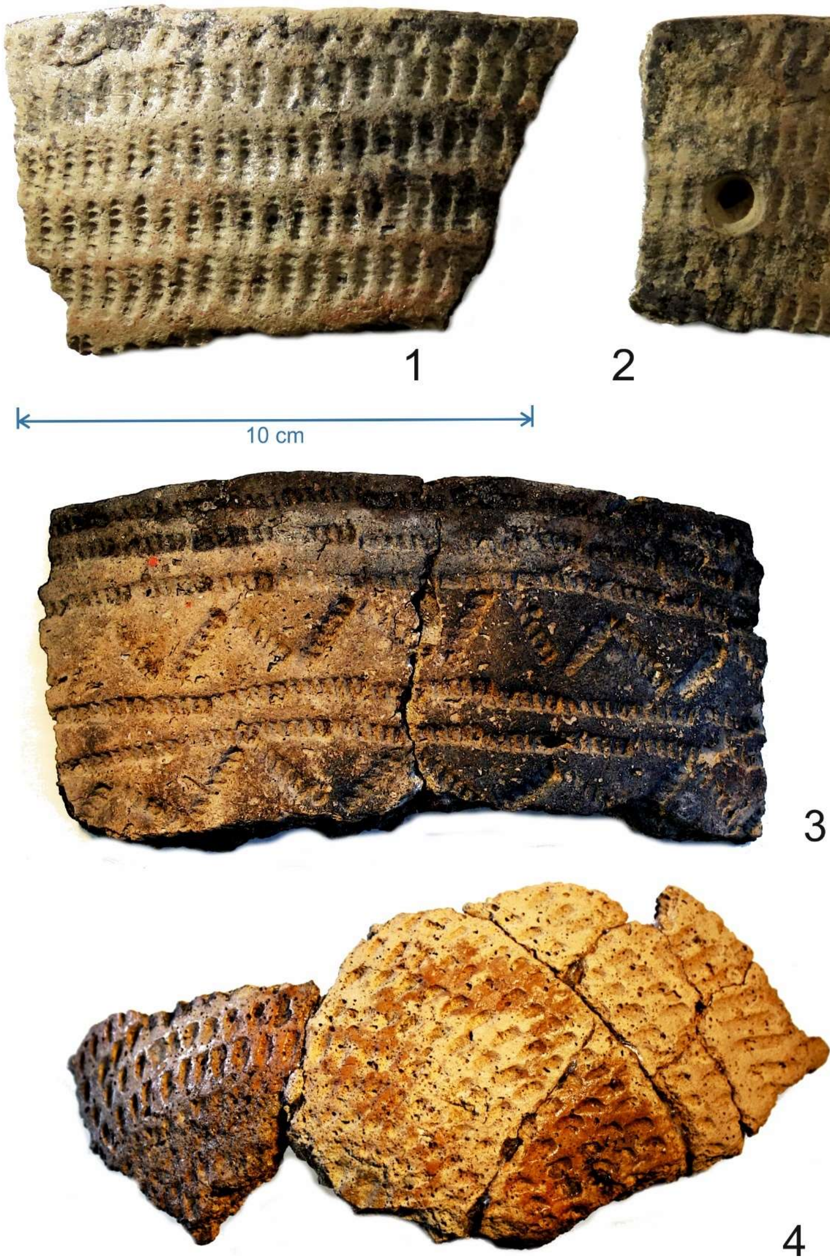

Figure 2.6. Jäkärlä Ware from Finland. 1-2) KM 6673:5 Teuva Komsinkangas, 3) KM 14594: 392 Espoo Mynt (Hela-3166: 5210±40 BP), 4) KM 15133:5-6 Mynämäki Aisti (Hela-3075: 7450±49 BP, "an outlier"). Photo: Petro Pesonen.

2.2.2 MIDDLE NEOLITHIC (CA 3900–2900 CALBC)

The beginning of Middle Neolithic period starts with the beginning of Typical Comb Ware (or Comb-Pit Ware in Russian terminology) and Rhomb-Pit Ware production. These two types of pottery were first thought to follow each other, but new interpretations see them as contemporary types, deriving from Pit-Comb Ware (Zhulnikov 2005; Khoroshun 2015; Vitenkova 2016; Tarasov et al. 2017). Their characteristics include a versatile use of temper materials, depending on the availability of raw materials in different regions (e.g. sand, crushed stone, organic materials, asbestos, e.g. Pesonen 2004; Nordqvist & Mökkönen 2015). The decoration of Typical Comb Ware usually consists of horizontal zones with simple pit- and comb-stamp rows or more complex geometric patterns forming fields (Fig. 2.7). Representations of waterbirds and humans exist both in Typical Comb Ware and Rhomb-Pit Ware (Pesonen 1996 c; Nieminen & Ruonavaara 1984; Äyräpää 1953; Gurina 1961; Utkin 1989; Taavitsainen 1982; Huurre 1986). In Typical Comb Ware the rims are often thickened, and they practically always have decoration on top of them. In this dissertation (as well as in most papers by the author and in many other modern studies as well), the division of Typical Comb Ware into an older and younger type (Ka 2:1 and Ka 2:2, *sensu* Europaeus-Äyräpää 1930) has not been followed (see short discussion on the matter in Pesonen 1999 a: 193). Rhomb-Pit Ware is similar to Typical Comb Ware in its basic forms and tempers, but its decoration carries the legacy of Pit-Comb Ware more clearly than Typical Comb Ware does, including the emphasis on pit-stamps, which in many cases are rhomb-shaped rather than round (Fig. 2.9; e.g. Vitenkova 1996 b; 2002).

Nordqvist and Mökkönen have recently (2015) suggested that the regional variation (in decoration, shape, and tempering) present in Typical Comb Ware is so great that “no single, pan-regional pottery types existed” (Nordqvist & Mökkönen 2015: 155). This obvious conclusion (which does not necessarily have a major impact on the chronology) has not been elaborated upon much further, but it has a bearing on e.g. illustrating the different ways that Typical Comb Ware spread throughout the area: in the southern part of the ancient Lake Saimaa, Typical Comb Ware appeared as a result of migration, while in the northern part of the lake system, it was the result of a slower development process (Nordqvist 2018: 101; Mökkönen & Nordqvist 2016; Mökkönen et al. 2017). These kinds of differences in methods of spread may have also led to the separation and development of various pottery styles.

The distribution of Typical Comb Ware is broad, reaching to Sweden in the west, to the Baltic States and Belorussia in the south, to the Arctic Circle, and to the northern and eastern shores of Lake Onega in the east (Fig. 2.8; e.g. Piezonka 2015; Nordqvist & Mökkönen 2015). The distribution of Rhomb-Pit Ware covers the eastern parts of eastern Fennoscandia, including much of the Karelian Republic and Leningrad Oblast (Fig. 2.8; Nordqvist 2015: 256).

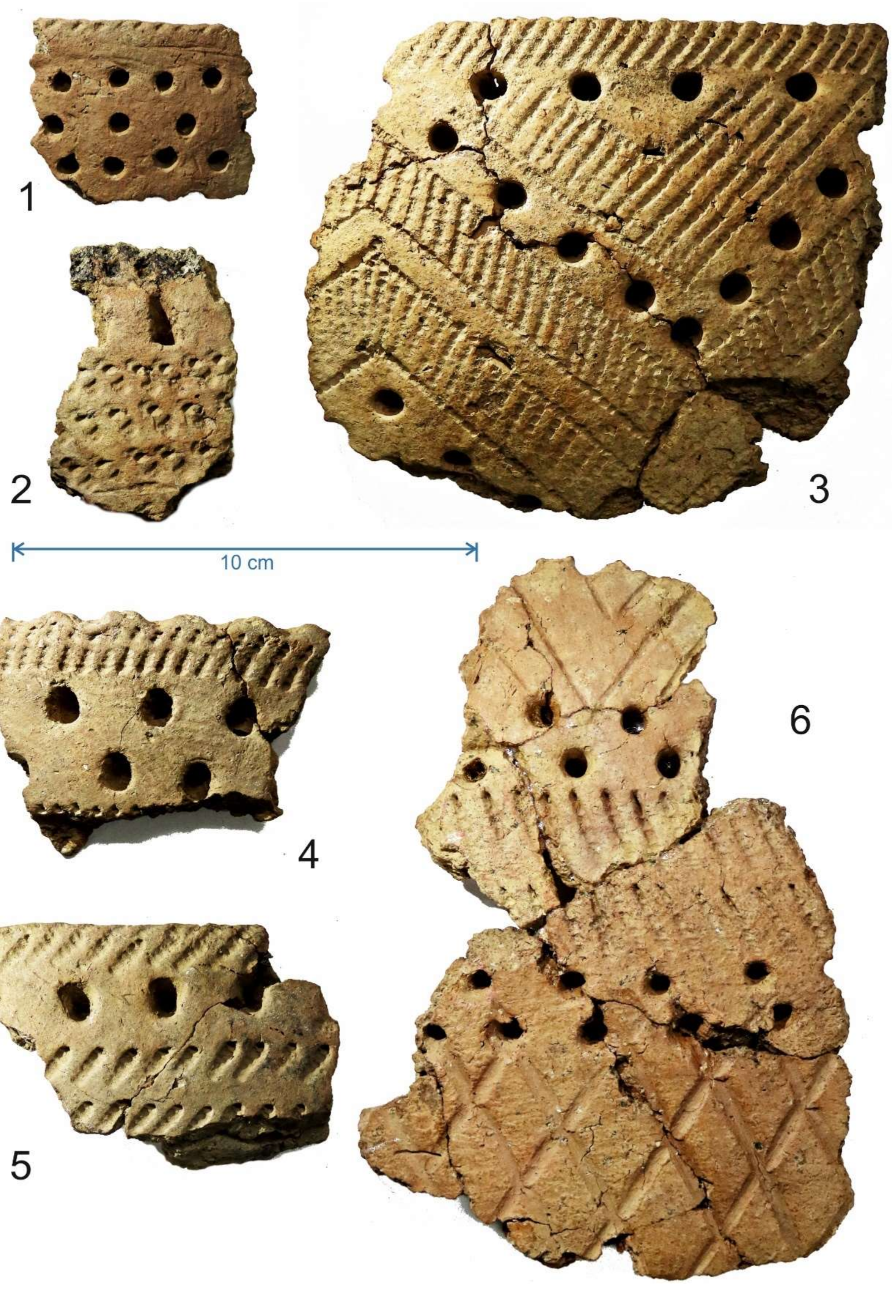

Figure 2.7. Typical Comb Ware from Finland. 1) KM 9135:3 Kerimäki Kankaanlaita, 2) KM 8787:108 Savonlinna (Sääminki) Pääskylahti (Hela-112: 4875±70 BP), 3) KM 8603:10 Lapinlahti Kärkkäinen, 4) KM 8690:4 Savonlinna (Sääminki) Pääskylahti, 5) KM 9135:3 Kerimäki Kankaanlaita, 6) KM 8787:53 Savonlinna (Sääminki) Pääskylahti. Photos: Petro Pesonen.

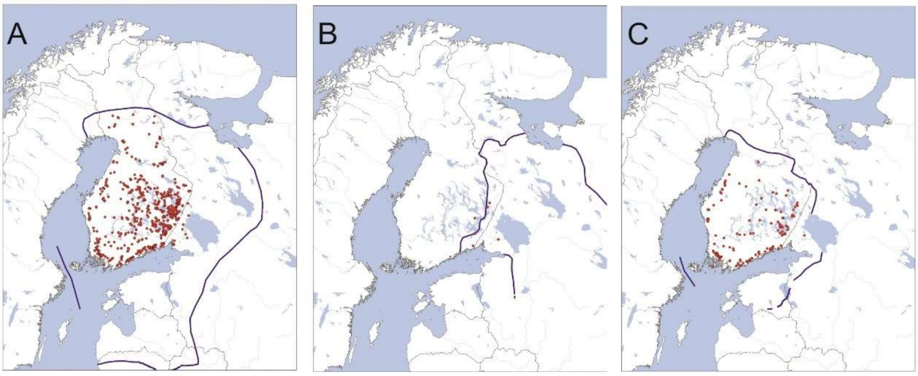

Figure 2.8. The distribution of A) Typical Comb Ware, with the general distribution area adopted from Nordqvist & Mökkönen 2018: Fig. 32, with addition from Piličiauskas et al. 2019; B) Rhomb-Pit Ware, with the general distribution area adopted from Nordqvist 2015: 256; C) the approximate distribution of Late Comb Ware (Uskela Ware, Sipilänhaka Ware, and other variants in the region), with the general distribution area for the eastern Baltic and Russia adopted from Nordqvist 2015: 256. For Finland and ceded Karelia (formerly part of Finland), the points of the find-places were identified from the Kipot ja Kielet –database, University of Turku (points in database until 12/2019).

The Late Middle Neolithic pottery styles present in eastern Fennoscandia include Late Comb Ware, Pyheensilta Ware, Pitted Ware, Kierikki Ware, Voynavolok Ware, Orovnavolok Ware, Zalavruga Ware, and Pöljä Ware. Only Late Comb Ware has been radiocarbon dated during my dissertation project, but there are now rather comprehensive studies and new dating results for many of these Middle Neolithic pottery types (Nordqvist & Mökkönen 2018; Mökkönen & Nordqvist 2018).

Late Comb Ware was traditionally divided into two chronological variants by Europaeus-Äyräpää (1930): Older Late Comb Ware (Ka 3:1 or Uskela Ware) and Younger Late Comb Ware (Ka 3:2 or Sipilänhaka Ware). However, this division has largely been left out of use because of the lack of Sipilänhaka-like assemblages (e.g. Asplund 1997). The term Late Comb Ware is very often ascribed to all potteries carrying the tradition of Typical Comb Ware. Uskela Ware is a variant present especially in the coastal areas of Finland, and to some extent also in the Karelian Isthmus and Estonia (Vikkula 1981; Kholkina 2018; Kriiska 1995; Lang & Kriiska 2001), even though a basic typological study of the pottery has not been accomplished. The original definition of Uskela Ware concentrated on organic tempered vessels (Europaeus-Äyräpää 1930: 186), although similarly decorated and shaped pots also exist in mineral tempered versions (e.g. Vikkula 1981; Leskinen 2003; Pesonen 2004), leading to the variable use of terminology, e.g. “Late Comb Ware of the inland” (Pesonen 1996 a: 159; Nordqvist 2018: 66).

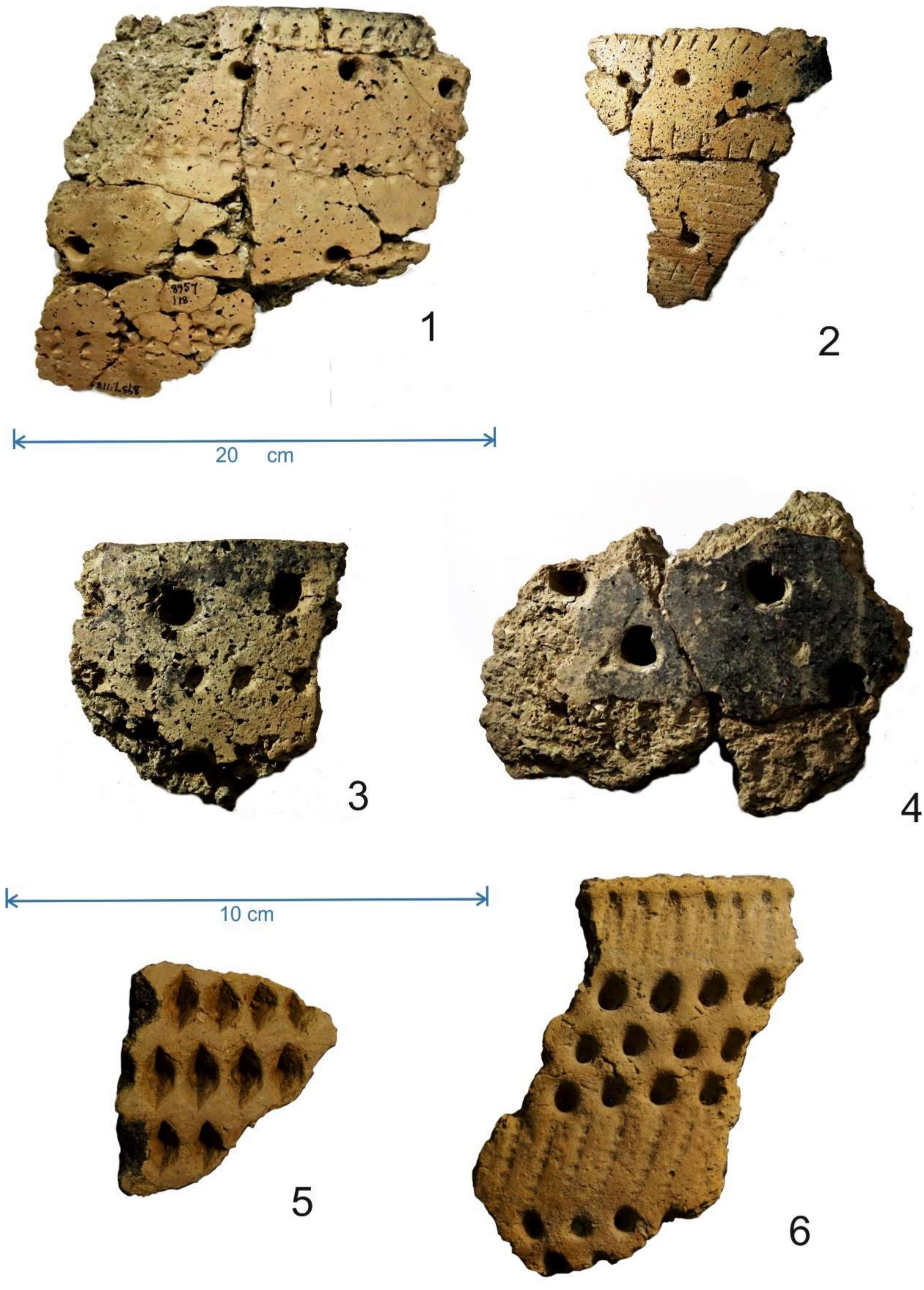

Figure 2.9. Late Comb Ware from Finland (1–4) and Rhomb-Pit Ware from Russia (5–6). 1) KM 8957:116 Siuntio Tallmalmsåsen, 2) KM 8957:72 Siuntio Tallmalmsåsen, 3) KM 8957:123 Siuntio Tallmalmsåsen, 4) KM 8957:61 Siuntio Tallmalmsåsen, 5) No 784/1074 Pegrema I (GrA-63684: 4825±35 BP), 6) No 721/1090 Pegrema I (GrA-63733: 4720±35 BP). Photos Petro Pesonen (1–4), Teemu Mökkönen (5–6, reproduced with permission from Nordqvist & Mökkönen 2018: Fig. 4).

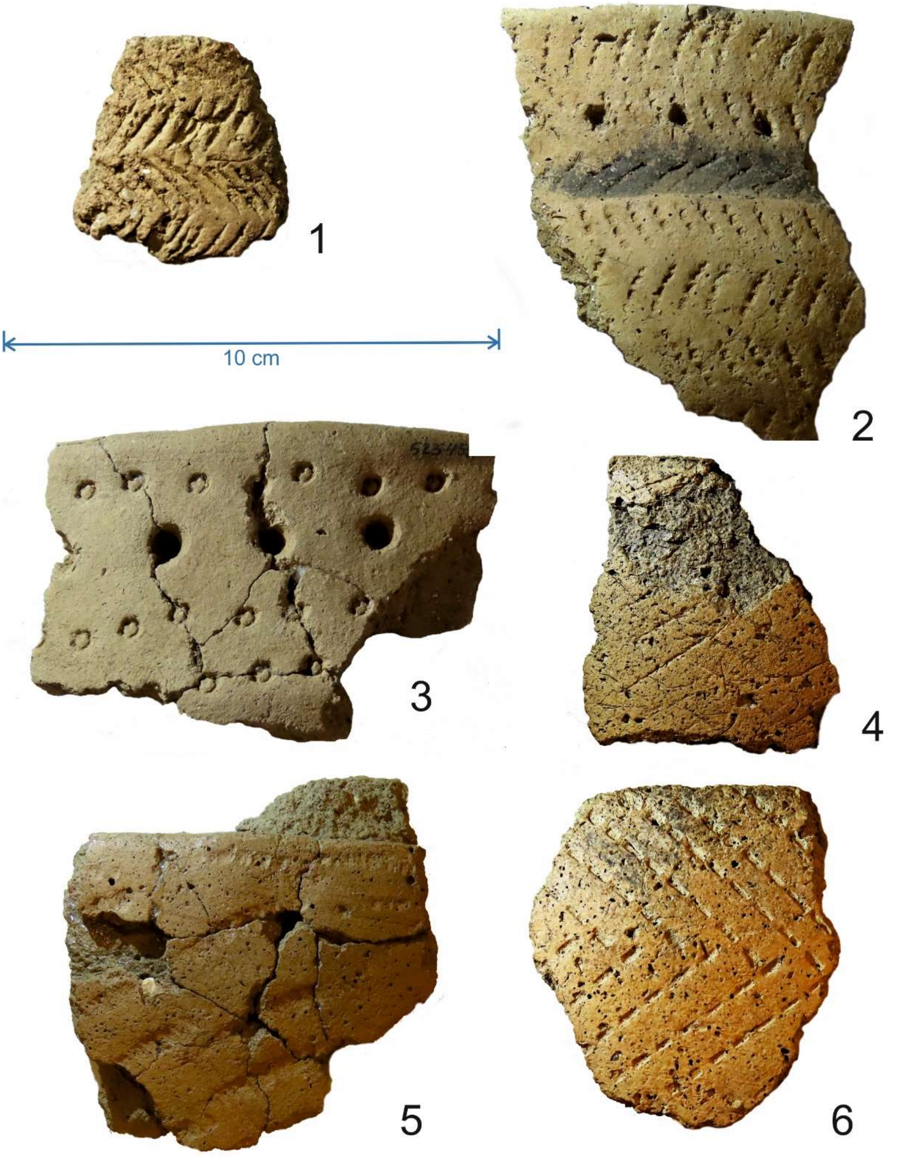

Figure 2.10. Pitted Ware from Finland and Åland (1–3) and Pyheensilta Ware from Finland (4–6). 1) KM 8683:12 Nousiainen Kukonharja, 2) ÅM 552:82 Geta Norsträsk, 3) ÅM 523:459 Saltvik Kriko, 4) KM 11121:7 Mynämäki Pyheensilta, 5) KM 10903:232 Mynämäki Pyheensilta, and 6) KM 15328:143 Mynämäki Pyheensilta. Photo: Petro Pesonen.

Irrespective of the variable use of temper materials, where organic tempers are most common in the coastal areas, the usual decoration elements are pits and small pit-like stamps, lines, and various stamps (but only seldom comb-stamps), organized in horizontal rows (Fig. 2.9). The rim is more often straight than thickened, and rim-top decoration is rare (Vikkula 1981). However, the exact line of separation between Typical and Late Comb Ware, and even Zalavruga Ware and other Late Middle Neolithic varieties, can sometimes be difficult to detect (e.g. Nordqvist & Mökkönen 2015), so long as typologies are solely descriptive and based on a limited number of sites and specimens as well as outdated definitions. In the end, there probably are geographically, typologically, and chronologically sliding criteria differentiating between these types, as seems to be case with Late Middle Neolithic asbestos and organic tempered potteries in the same area (Nordqvist & Mökkönen 2018; Mökkönen & Nordqvist 2018; Gerasimov et al. 2019).

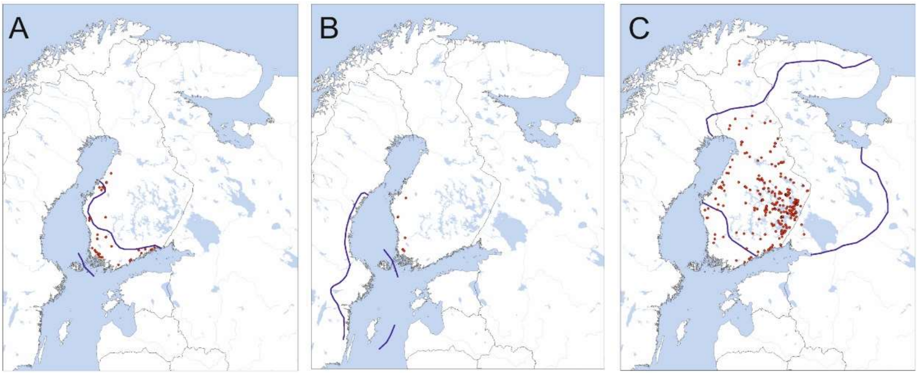

Figure 2.11. A) The distribution of Pyheensilta Ware, with the general distribution area adopted from Nordqvist 2015: 256; B) the approximate distribution of Pitted Ware, with the general distribution area adopted from Vanhanen 2019: Fig. 16; C) the distribution of Middle and Late Neolithic asbestos and organic tempered wares, with the general distribution area adopted from Nordqvist 2018: Fig. 33. For mainland Finland and ceded Karelia (formerly part of Finland), the locations of the find-places (Pyheensilta, Pitted Ware, Kierikki Ware, Pöljä Ware, Zalavruga Ware, Voynavolok Ware, and Orovnavolok Ware) were identified from the Kipot ja Kielet – database, University of Turku (points in database until 12/2019).

The continuation of coastal pottery types (Jäkärlä Ware and Uskela Ware) into Pyheensilta Ware has been suggested (e.g. Vikkula 1984; Asplund 1995; Äyräpää 1956), but the roles of Corded Ware, Pitted Ware, and even Volosovo Ware have also been brought forth (e.g. Vikkula 1984; Meinander 1984). Pyheensilta pottery is mostly porous, organic tempered pottery, with decoration consisting of comb-stamps and lines, other stamp shapes (e.g. oval and ring-form stamps), and fingernail impressions, but without any pits (Fig. 2.10). The straight vessel rims are usually decorated, and the base is pointed or rounded. The decoration covers the whole surface of the vessel. Most of the Pyheensilta pots are the usual "egg-shaped" types, but some feature a profiling of the wall and thus contacts to the Pitted Ware tradition in Sweden and the Åland Islands (e.g. Vikkula 1984; Äyräpää 1956; Larsson 2009). The distribution of Pyheensilta pottery is clearly coastal (Fig. 2.11), and the role of Pitted Ware culture in this may have been a substantial one, but the latter pottery finds are still rather rare in continental Finland despite the wealth of material in the Åland Islands (Fig. 2.11; e.g. Stenbäck 2003; Vikkula 1987; Miettinen 1999; Laulumaa 2005; Vanhanen 2019).

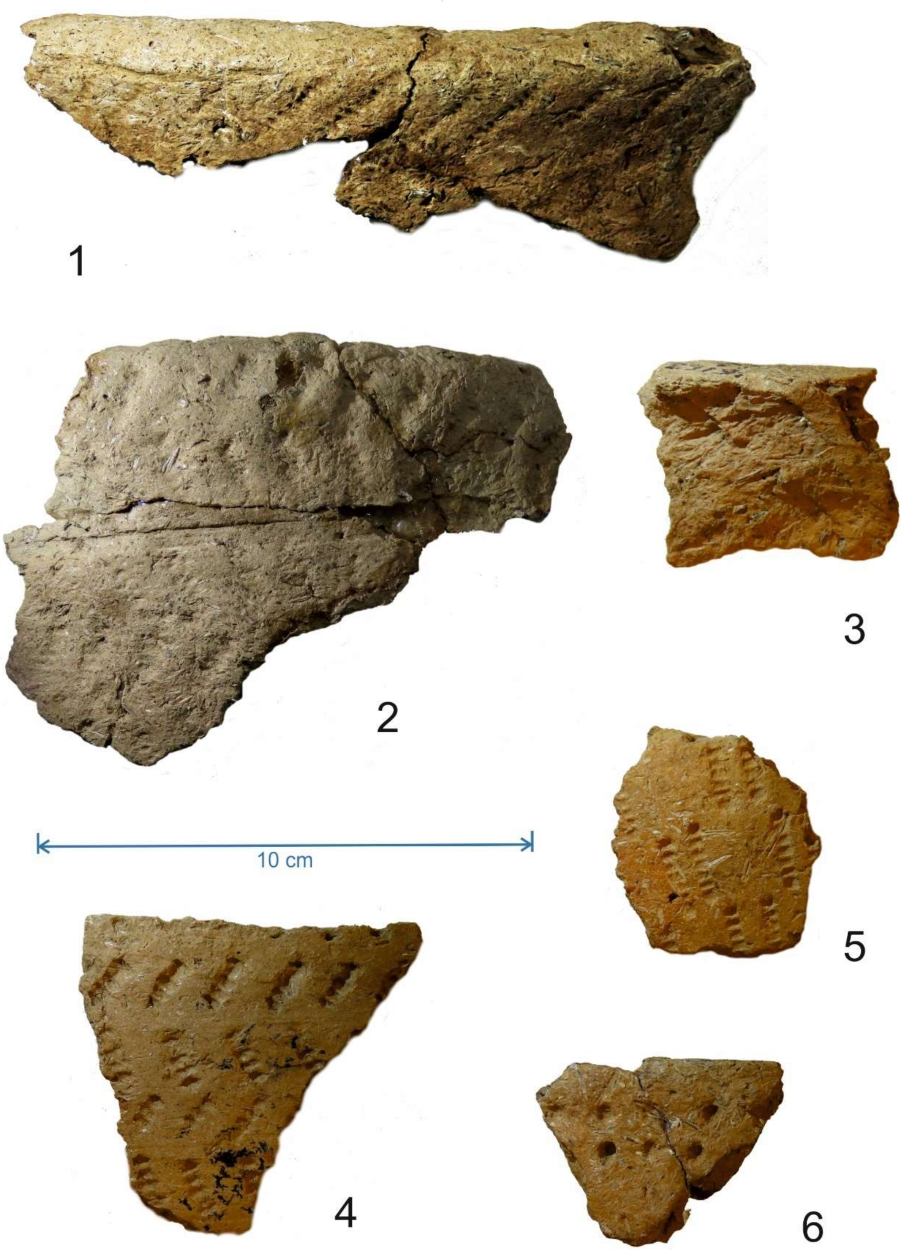

Figure 2.12. Middle and Late Neolithic Asbestos and Organic tempered Wares from Finland, 1–2) Pöljä Ware, 3–4) Kierikki or Pöljä Ware, and 5–6) Kierikki Ware. 1) KM 8981:6 Siilinjärvi Pöljä, 2) KM 8981:8 Siilinjärvi Pöljä, 3) KM 15163:2 Nurmes Hiekkamäki, 4) KM 18270:1 Kitee (Kesälahti) Sirnihta, 5) KM 16140:1579 Oulu (Yli-Ii) Kierikki, and 6) KM 16140:29 Oulu (Yli-Ii) Kierikki. Photo: Petro Pesonen.

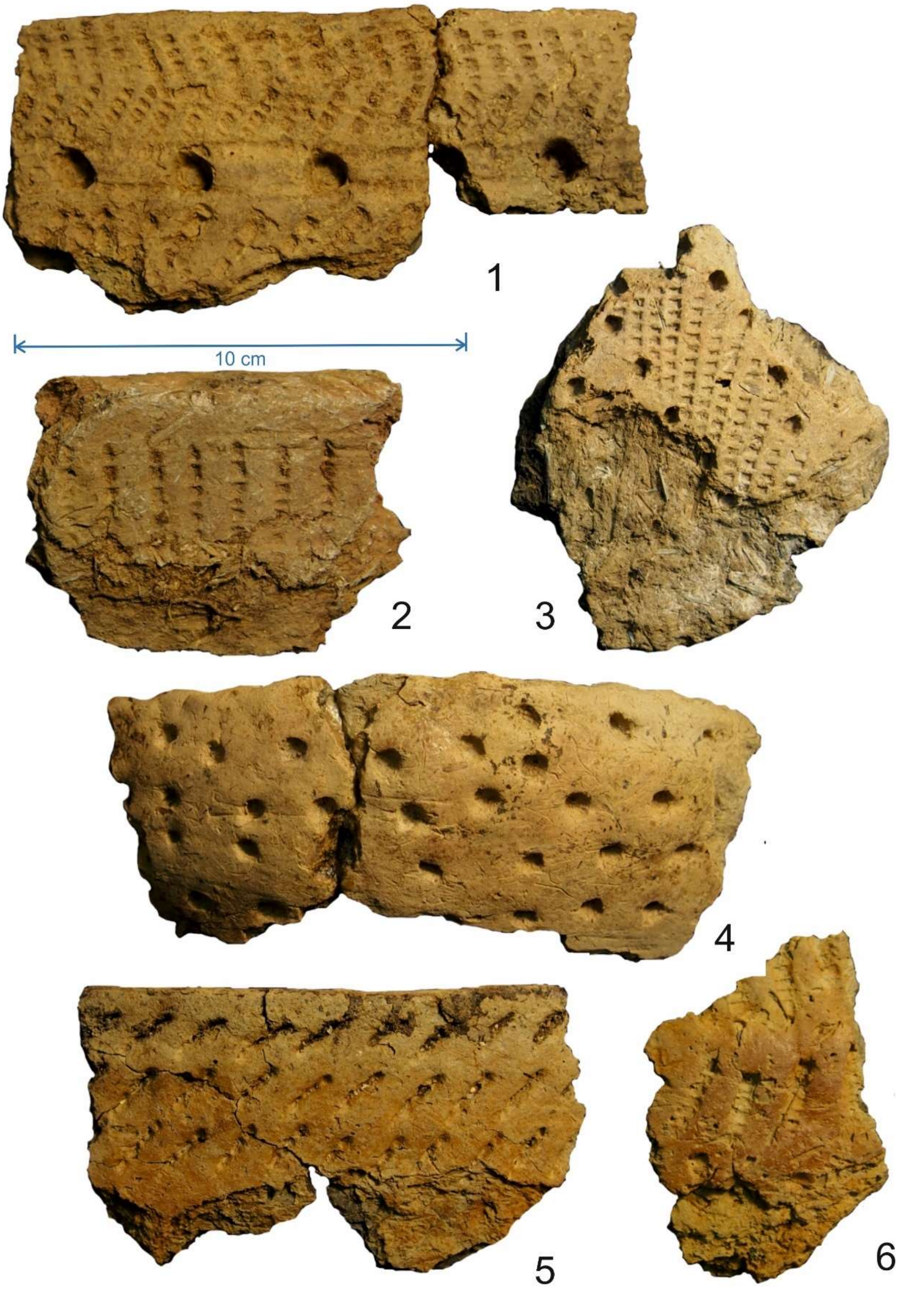

Figure 2.13. Middle and Late Neolithic Asbestos and Organic tempered Wares from Russia. 1) Zalavruga Ware, No 378/297, Zalavruga 1 (GrA-63559: 4580±35), 2) Voynavolok Ware, No 2PGU/1473, Voynavolok XXVII (GrA-63562: 4365±35), 3) Voynavolok Ware, No 2410/9, Pervomayskaya I (GrA-63682: 4710±35), 4) Orovnavolok Ware, No 2148/250, 867, Tunguda XV (GrA-63583: 4570±35), 5) Orovnavolok Ware, No 2148/468, Tunguda XV (GrA-63582: 4515±35), 6) Orovnavolok Ware, No 2148/572, Tunguda XV (GrA-63584: 4435± 35). Photos Teemu Mökkönen (reproduced with permission from Nordqvist & Mökkönen 2018: Fig. 5–7).

The asbestos and organic tempered Middle and Late Neolithic ceramics cover a large part of eastern and northern Finland, Murmansk oblast, the Karelian Republic, and Leningrad oblast (Fig. 2.11; Zhulnikov 1991; 1999; 2005; 2007; Nordqvist 2015; 2018; Mökkönen & Nordqvist 2018). The exact typology and chronology of these various potteries is still not clear, and the definitions have been made nation-wise, i.e. Kierikki Ware in Finland parallels Voynavolok Ware in Russia, and Pöljä and Jysmä Ware in Finland parallels Orovnavolok Ware in Russia (e.g. Tarasov et al. 2017; Zhulnikov 1999). Furthermore, Zalavruga Ware has a lot in common with Kierikki Ware, and northern Finnish (Typical) Comb Ware (Tarasov et al. 2017; Mökkönen & Nordqvist 2018; Nordqvist 2018; Zhulnikov 1999; 2007). A shared characteristic of these already recognised pottery types is the use of asbestos and/or organic materials as a temper material. Otherwise, the decoration and the shapes of pots are variable (Fig. 2.12; Fig. 2.13; Nordqvist & Mökkönen 2018; Mökkönen & Nordqvist 2018; Nordqvist 2018; Tarasov et al. 2017).

2.3 CORDED WARE AND ITS POSITION IN THE LATE AND FINAL NEOLITHIC OF EASTERN FENNOSCANDIA

The Late Neolithic in eastern Fennoscandia is characterised by the appearance of Corded Ware. Other contemporaneous ceramic types include Pöljä Ware in eastern and northern Finland and the Karelian Republic, and Palayguba Ware, which is present mainly in the Karelian Republic. The distribution of Corded Ware is primarily limited to the southern parts of the region, i.e. southwest of the imaginary curved line between Kokkola in Finland and Priozersk (Käkisalmi) in Russia (Fig. 2.14). Some isolated finds of Corded Ware pottery have also been found north of this line (Nordqvist & Häkälä 2014: Fig. 3). Several battle axes and shouldered axes connected with Corded Ware have been discovered outside the main area of the culture, illustrating contacts and interaction with the surrounding areas (Nordqvist & Häkälä 2014: Figs. 5–10). Corded Ware in eastern Fennoscandia is a part of the broader Battle Axe/Corded Ware cultural sphere in Europe. Eastern Fennoscandian Corded Ware includes at least two subgroups: Finnish and Estonian Corded Ware, of which the latter is organic tempered pottery (Nordqvist 2018: Fig. 36). In addition, Fatyanovo Ware distribution reaches the shores of Lake Ladoga in the southeastern corner of eastern Fennoscandia (Nordqvist 2016: Fig. 1). The contacts between the Finnish, Estonian, and Swedish Corded Ware potters were vivid, as shown by the flow of material culture across the Baltic Sea (Holmqvist et al. 2018).

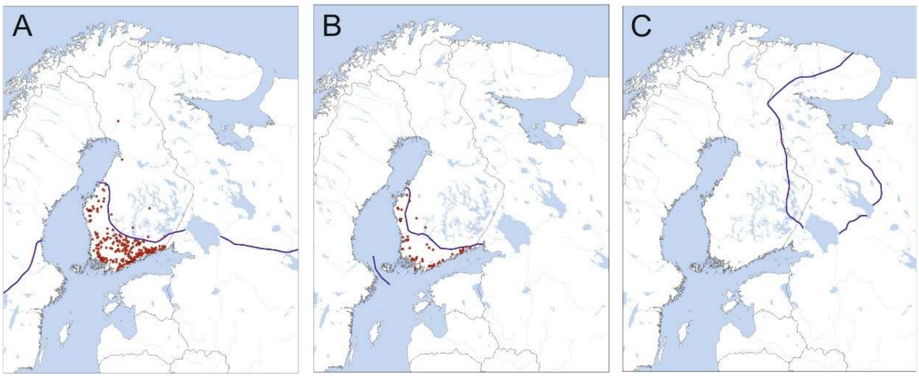

Figure 2.14. A) The distribution of Corded Ware, with the general distribution area adopted from Nordqvist 2018: Fig. 36 (Finland and Russia) and Vanhanen 2019: Fig. 16 (Sweden); B) the distribution of Kiukainen Ware, with the general distribution area adopted from Nordqvist 2015: 258; C) the distribution of Palayguba Ware, with the general distribution area adopted from Nordqvist 2015: 258. For Finland and ceded Karelia (formerly part of Finland), the points of the find-places were identified from the Kipot ja Kielet –database, University of Turku (points in database until 12/2019). Some possible Palayguba find locations in Finland are not shown due to their uncertain status.

The Corded Ware in Finland is usually tempered with grog (crushed pottery), but mineral and organic tempers also rarely occur (Edgren 1970). In contrast, mineral and organic tempers are more common than chamotte temper on the Karelian Isthmus (Nordqvist 2016). Corded Ware pottery includes beakers, cups, and jars (and some occasional amphoras), of which the beakers are generally thinner and smaller than the "domestic" jars. Decoration covers the upper part of the vessel body, and often also the bottom of the vessel, with the main elements featuring cord impressions and drawn lines (Fig. 2.15; Edgren 1970; Malmer 1962; Larsson 2009). The location of Corded Ware settlement sites in the proximity of coastal meadows, as well as small river valleys, has long been recognised as an indication of the agricultural – or pastoral, at least – livelihood of the Corded Ware societies (Äyräpää 1973), further supported by finds of milk remains in the pottery (Cramp et al. 2014; Pääkkönen et al. 2019). In Finland and Karelia, the distribution contrasts to that of the roughly contemporary Pöljä Ware, providing grounds to discuss the demographic border reflected in these pottery varieties (e.g. Äyräpää 1952; Edgren 1984; 1997).

In the coastal region of Finland, Kiukainen culture and its ceramic counterpart, Kiukainen Ware, prevailed after the Corded Ware period, forming the Final Neolithic in Finland (Fig. 2.14; see Nordqvist & Mökkönen 2017). The pots were straight-walled and even-based, "rough" household ceramics, decorated with various kind of stamps and pits that cover only the upper part of the vessel body (Fig. 2.16; Meinander 1954; Asplund 2008: 204–205). Lipid analyses of Kiukainen pottery indicate the processing of aquatic as well as ruminant (possibly also dairy) fats in the pots (Cramp et al. 2014; Pääkkönen et al. 2019). In the lake region of Finland, the so-called Middle

Zone ceramics may have appeared during this time, but this phenomenon is still poorly understood (Carpelan 1979; also Nordqvist 2018: 113). In the eastern parts of the area, Palayguba Ware, which shares some features with Orovnavolok Ware, is partly contemporary with Kiukainen and Pöljä Wares (Fig. 2.16; Zhulnikov 1999; Tarasov et al. 2017). Palayguba Ware has also been connected with Corded Ware, especially the Fatyanovo cultures (Zhulnikov 1999).

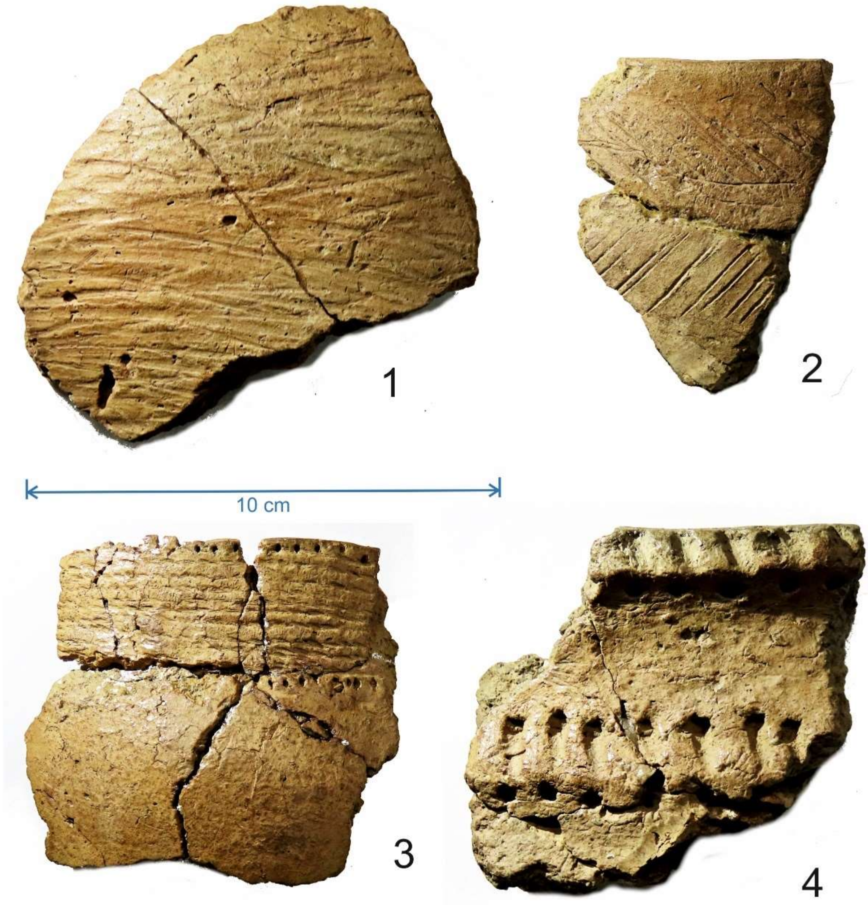

Figure 2.15. Corded Ware from Finland. 1) KM 8709:29 Kirkkonummi Tengo Nyåker, 2) KM 8709:22 Kirkkonummi Tengo Nyåker, 3) KM 8826:2 Sastamala (Kiikoinen) Uusi-Jaara, 4) KM 8709:35 Kirkkonummi Tengo Nyåker. Photo: Petro Pesonen.

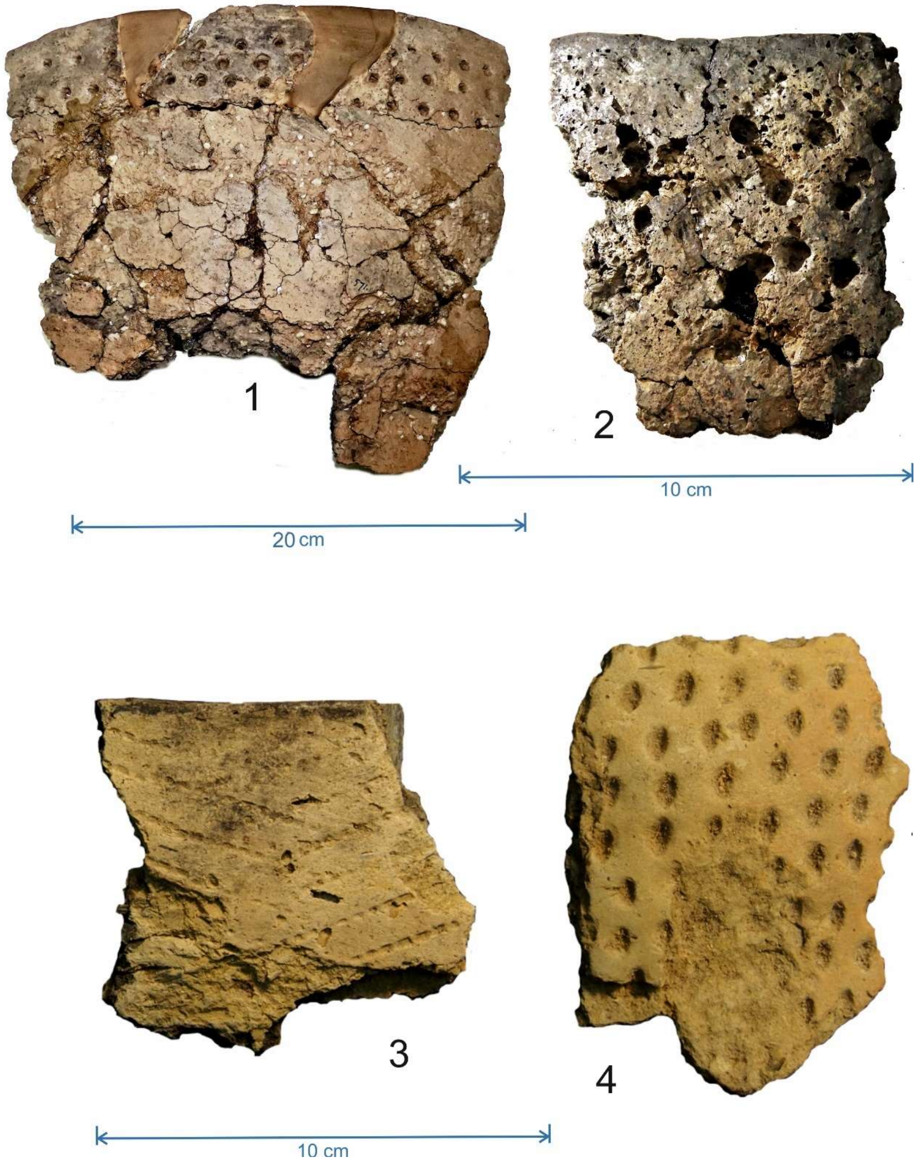

Figure 2.16. Kiukainen Ware from Finland and Palayguba Ware from Russia. 1-2) Kiukainen Ware, KM 8773:571, Turku (Maaria) Kärsämäki, 3) Palayguba Ware, No 896/252, Sheltozero XII (GrA-63585: 3815±35 BP), 4) Palayguba Ware, No 896/"232", Sheltozero XII (GrA-63586: 3725±35 BP). Photos Petro Pesonen (1-2), Teemu Mökkönen (3-4, reproduced with permission from Nordqvist & Mökkönen 2018: Fig. 7).

2.4 RADIOCARBON CHRONOLOGIES OF NEOLITHIC POTTERY IN EASTERN FENNOSCANDIA

2.4.1 EARLY NEOLITHIC

Neolithic pottery types were one of the earliest targets of radiocarbon dating in Finland. Curiously, however, the first radiocarbon dates connected with Early Neolithic ceramics were of Jäkärlä Ware, which can be considered a marginal group in the wider context of early ceramic distribution in the region (see Meinander 1971). The first radiocarbon dates of Finnish Sperrings Ware contexts were obtained in the late 1970's from the Kraviojankangas site in Kokemäki and the Haveri site in Kemijärvi (Siiriäinen 1973; Nuñez 1990). However, a radiocarbon chronology incorporating more data was only developed later, in the extensive overviews compiled by Christian Carpelan (e.g. 1979; 1999; 2002). In the 2000´s, a series of radiocarbon dates with interesting results were derived from sites in the Åland Islands, on the western margin of Sperrings Ware distribution (Stenbäck 2003; Hallgren 2008; 2009). The radiocarbon dates confirmed the antiquity of Sperrings Ware in relation to other ceramic groups, as already suggested by Aarne Europaeus in the 1920´s (e.g. Europaeus 1926; Europaeus-Äyräpää 1930). In these schemes, Sperrings 1 Ware was dated to ca. 5200–4500 calBC, and its successor Sperrings 2 Ware to ca. 4500–3900 calBC (e.g. Carpelan 2002). The newest general overview of the radiocarbon dates places Säräisniemi 1 at c. 5200–4400 calBC and Sperrings at c. 5000–4000 calBC (with both Sperrings 1 and 2 included, Pesonen & Leskinen 2009: 302).

The eastern viewpoint on ceramic chronology was long distracted by the uncertain nature of their radiocarbon dates, but new advances and developments have addressed the situation, and nowadays a good corpus of radiocarbon dates has also been established on the Russian side of eastern Fennoscandia (e.g. Piezonka 2015; Nordqvist 2018). In Russian Karelia, the majority of Sperrings Ware sites are located on the shores of the large Lake Onega, with many occurrences also on the shores of Lake Ladoga and the White Sea. This is why the chronology of Sperrings Ware in Russian Karelia was also long dictated by the shoreline chronologies constructed for the basins in question (e.g. German 2009 and the references therein). The radiocarbon dates for Sperrings Ware in Karelia span from 6480±70 to 5460±80 BP (Vereshchagina 2003; German 2009; Piezonka 2008; 2015; Piezonka et al. 2017), equating to c. 5600–4100 calBC. One pre-Sperrings –titled Early Comb Ware vessel has been dated from the Tudozero site in southern Onega to 6660±32 BP (AAR-17174; Piezonka et al. 2017).

Ari Siiriäinen (1978) published the first radiocarbon dates connected with Säräisniemi 1 (Sär 1) ceramics in Finland. These dates, together with the shoreline chronology (Siiriäinen 1971), place the Säräisniemi 1 phase in the same chronological horizon as Sperrings 1 Ware in Finland, contrary to the earlier opinions supporting contemporaneity with Typical Comb Ware. During the 1990´s, a number of dates were derived from several sites in connection with excavations, and also by a larger project devoted to the study of the prehistory of northern Finland (e.g. Carpelan 2004 a). The most comprehensive work on Säräisniemi 1 was published by Markku Torvinen (2000), but some chronological schemes had already been published earlier (Carpelan 1979; 1999). According to Torvinen (2000: 17), the Finnish Sär 1 would date to 6140–5520 BP (c. 5200-4420 calBC). Carpelan (1999: 273) dates Sär 1 to c. 5000–4500 calBC.

In Norway, the dating of Sär 1 was first based on charcoal datings (e.g. Helskog 1980), but several new food crust datings have changed the picture remarkably. The new dates were presented by Marianne Skandfer in her PhD Thesis (2003), as well as later articles on the subject. According to Skandfer, Sär 1 is dated to 5565–4620 calBC (Skandfer 2005: 6), to c. 5400–4500 calBC (Skandfer 2009: 357), or 5630–4100 calBC in Finnmark (Skandfer 2011: 171).

In Russian Karelia, there were no direct radiocarbon dates of Säräisiniemi 1 ceramics until Henny Piezonka had one vessel from Kalmozero 11 dated (Piezonka 2008). On the other hand, in the Kola region, several Sär 1 connected datings exist, but with a huge chronological span over centuries, c. 4800–3100 calBC (Piezonka 2008; 2011). From the Veksa site, in Vologda Oblast, various radiocarbon dates connected with the Early Neolithic have been published, including one (KIA-33928, 6105±30 BP) of the so-called "Northern type", which has been associated with the genesis of Säräisniemi 1 Ware (Piezonka et al. 2017). This, however, in addition to the other Comb-Pit ceramics from the site, probably represent earlier evolutions compared to other pottery traditions in eastern Fennoscandia, and their direct association with e.g. Sperrings Ware and Pit-Comb Ware is not certain.

Late Early Neolithic pottery, along with Sperrings 2 Ware, was only sporadically radiocarbon dated in eastern Fennoscandia. Jäkärlä Ware finally received new context dates over 20 years after the early series from the Sauvo Nummenharju and Eura Kolmhaara sites (Meinander 1971), when a set of dates was published from the Kemiönsaari Nöjis site (Asplund 1995). This, however, did not much help the situation, as these dates only extended the length of the Jäkärlä period for 1500 years, with the median value for the Nöjis site being 4710 calBC (Asplund 1995). Along with the problems in the shoreline chronology of Southwest Finland, the chronology of Jäkärlä Ware seemed to be a mystery (Asplund 2006; Tiitinen 2011), until the advent of the new dating programme of Jäkärlä charred crust and burned bone context dates (Paper IV).

Early Asbestos Ware suffered from a lack of both direct and context dates until our project to date the Vuoksi catastrophe (Paper IIII). Before that, only a few radiocarbon dates were connected with Early Asbestos Ware, and its chronology was based strongly on the uncalibrated shoreline chronology of inland Finland and coastal Ostrobothnia (e.g. Pesonen 1996 a; 1996 b). Since the development of the chronology presented in Paper III, only one radiocarbon date connected to Early Asbestos Ware has been published (Nordqvist & Mökkönen 2016 a). Until recently, the chronology of Pit-Comb Ware – despite the wide availability of material – has been based mainly on context dates. Pit-Comb Ware is currently dated to 4800/4600–4000/3700 calBC (Nordqvist 2018; Tarasov et al. 2017; Nordqvist & German 2018); the uncertainties are partly due to typological issues within Pit-Comb Ware (Nordqvist & German 2017). In Finland, no radiocarbon dates connected with Pit-Comb Ware have been established.

2.4.2 MIDDLE AND LATE NEOLITHIC

The radiocarbon chronology of Typical Comb Ware is by far the most studied of the Neolithic groups. The first radiocarbon series from Finland already included Typical Comb Ware context dates (Meinander 1971), and ever since, due to its high visibility and the large number of finds, there have been many radiocarbon dates associated with Typical Comb Ware. The first direct dates from charred crusts and birch bark tars were ascertained in the late 1990's (Halinen 1997; Pesonen 1999 a; 2004; Leskinen 2003), and it was soon clear that this material yielded on average much later results than the radiocarbon dates from context charcoals (Pesonen 1999 a; Fig. 2). These dates finally moved the time span for Typical Comb Ware into the 4th Millennium calBC, and the old estimates of ca. 4350–3800 calBC (Meinander 1971), ca. 4200–3600 calBC (Siiriäinen 1974), ca. 4300–3550 calBC (Nuñez 1978), or ca. 4350–3800 calBC (Matiskainen 1979) had to be rejected. In fact, the advent of the AMS-technique and the determination of direct dates shifted the whole sequence ca. 500 years later than the context dates had suggested. The reason for this shift has not yet been fully determined, although the use of old context dates with wide margins of error has been suspected (Pesonen 1999 a; Paper IV; also Nordqvist 2018: 68). The few direct or context Typical Comb Ware dates from the Karelian Republic and Leningrad Oblast (e.g. Nordqvist 2018), in Estonia (Kriiska et al. 2007), and in Sweden (Halén 1994; Färjare 2000; also Nordqvist et al. 2011) do not change the big picture much but make it possible to explore local developments within Typical Comb Ware.

The chronology of Rhomb-Pit Ware lies outside the immediate scope of this dissertation, but some interesting new radiocarbon dates have recently been published (Nordqvist & Mökkönen 2016 b; Tarasov et al. 2017), and the type is now dated to ca. 3600–3100 calBC (Skorobogatov et al. 2016). This places Rhomb-Pit Ware in the same chronological milieu as Late Comb Ware, and possibly also establishes a comparable genesis as a successor to Typical Comb Ware (or Comb-Pit Ware in Russia). The radiocarbon chronology of Comb-Pit

Ware and Rhomb-Pit Ware overlaps in the eastern parts of eastern Fennoscandia (Nordqvist & Mökkönen 2016 b), as it does between Typical Comb Ware and Late Comb Ware in the western parts of the area (Leskinen 2003; Pesonen & Leskinen 2009; Paper IV).

The radiocarbon chronology of Late Comb Ware was properly studied for the first time with the material from the Maarinkunnas site in Vantaa, where Late Comb Ware seemed to partly overlap with Typical Comb Ware (Leskinen 2003). Later, however, this overlap was interpreted as being at least partly due to the marine reservoir effect (Paper IV). Estonian Late Comb Ware radiocarbon dates fall in the period between 4860±60 BP and 4050±80 BP, i.e. 3640±80 calBC and 2620±130 calBC (Jussila & Kriiska 2004: 8), though new results indicate its continuation until ca. 1750 calBC (Kriiska et al. 2020). Pyheensilta Ware and Pitted Ware have no proper radiocarbon dates from mainland Finland, but Pitted Ware in Sweden is dated to ca. 3300–2300 calBC (e.g. Vanhanen 2019 and references therein).

Establishing the chronology of Middle and Late Neolithic asbestos and organic tempered ceramics is a matter of waiting for a proper typological study taking into account both Finnish and Russian material. For the time being, Kierikki Ware and Voynavolok Ware seem to be contemporaneous with Late Comb Ware, whereas Zalavruga and Orovnavolok are contemporaneous with both Late Comb Ware and Pyheensilta Ware. The long chronological span (almost 1500 years) of Pöljä Ware is a curious phenomenon and leads one to question its validity. While the very existence of a separate late variant of Jysmä Ware has now been rejected (Nordqvist 2018: 107-108), there is still a strong need for a reclassification of the material. The radiocarbon dates connected with these types are now quite numerous, allowing for an initial sequencing of the pottery types (e.g. Pesonen 2004; Nordqvist 2018; Mökkönen & Nordqvist 2018; Nordqvist & Mökkönen 2018).

The radiocarbon dating of Corded Ware in Finland relied for a long time on charcoal dates from three burial sites in southern Finland. These early dates were not in concordance with the wider European context of Corded Ware and its related groups. In particular, the early beginning date of 3200 calBC did not fit into international chronologies (see Mökkönen 2011a: 17). Obtaining radiocarbon dates from Corded Ware contexts has been difficult, as charred crust on pot walls is only rarely found and burnt bone material is scarce at the associated sites and are also often mixed with other periods of use. Only recently have radiocarbon dates for Corded Ware been collected and further samples analysed (Holmqvist et al. 2018; Paper V) in Finland and in the Karelian Isthmus (Nordqvist 2016). However, radiocarbon dates are numerous from the wider sphere of Corded Ware, and they follow much the same conclusions reached in our studies, with the dates spanning roughly from ca. 3000–2000 calBC (Paper V and references therein).

2.4.3 FINAL NEOLITHIC

Final Neolithic Kiukainen Ware has still not been properly dealt with by the means of radiocarbon chronology, though several dates now exist from the southwestern coastal area of Finland. The published direct charred crust dates span from 4000±70 BP to 3625±35 BP (Asplund 2008: 208; Lehtonen 2005; Luoto 2004), but unpublished dates have a little longer span, to 3518±38 BP (Appendix 2). Calibrated, these figures indicate a period between ca. 2840-1740 calBC. Taking into account the locations of Kiukainen Culture sites along the marine coast, the marine reservoir effect should also be taken into consideration in calibrating the dates.

There are so far only two published direct radiocarbon dates from Palayguba Ware, both from one site on the southeastern coast of Lake Onega in Russia. These dates correspond to the final centuries of the 3rd Millennium calBC, ca. 2300–2000 calBC (Nordqvist & Mökkönen 2018), but there is also one unpublished charred crust date from Finland that is possibly connected to Palayguba Ware, from the Kuusamo Somostenperä site in North Ostrobothnia, indicating a bit earlier age of 4115±75 BP (Hela-101; see Appendix 2), calibrated to 2870–2570 calBC (68,2% probability range). As the typology of the material has not been verified, however, the association remains only tentative.

3 THEORETICAL ISSUES RELATED TO POTTERY PRODUCTION AND RADIOCARBON DATING

3.1 CONTINUITY AND DISCONTINUITY IN POTTERY PRODUCTION

The chronology of the eastern Fennoscandian Neolithic is strongly dependent on ceramic typologies. Obviously, this does not necessarily have to be the case, but ceramic chronologies have guided the division of time and space into typo-chronological units since the early days of archaeological research, especially since the influential studies of Aarne (Europaeus-) Äyräpää in the first half of the 20th century (e.g. Europaeus 1922; Europaeus-Äyräpää 1930; Äyräpää 1956). In northwestern Russia, the framework created in the 1960's also following pottery phases (e.g. Gurina 1961; Kotchkurkina 1991; overview in Nordqvist 2018: 50-54).

Intertwined within the theoretical basis of ceramic chronology is the concept of continuity and development between ceramic styles, and their spread through the movement of populations and/or diffusion of innovations. This is easy to see in Äyräpää's classic study, where the chronological division of Comb Ware includes e.g. "superior" style (*hochstil*) and "degenerated" Comb Ware (Europaeus-Äyräpää 1930). The view of ceramics as a continuous technological development significantly hampers the possibility of considering any gaps or discontinuations in that development. The view from modern times to prehistory becomes easily fused into one continuous story, blurring the individual choices and local preferences that surely occurred in the background all the time. Another major problem is the accuracy of the timescale, or rather the lack of accuracy, which does not give credit to individual histories, referring instead to longer, over-arching processes.

One consequence of this view of gradual development is the denial, or at least underestimation, of the role of migrations or massive changes in population. When the foundational theory views external influences only as sporadic pushes with minor effects on material culture, there seems to be no room for the role of population replacement. The dichotomy between migration and diffusion has been discussed in the context of eastern Fennoscandia – in addition to other periods – especially as related to Corded Ware, where both views have had their supporters (discussion in e.g. Malmer 1962; Nordqvist 2016; Carpelan 1999; Edgren 1970; Luoto 1987; Lang 1995; Kriiska 2000). Currently, aDNA- and isotope-studies suggest that a high degree of variation and the large scale replacement of populations were occurring already in Stone Age societies (e.g. Der Sarkissian et al. 2013; Der Sarkissian 2011; Haak et al. 2008; 2010; Jensen et al. 2019; Malmström et al.

2009; 2015; Palo et al. 2009; Price et al. 2001; Mittnik et al. 2018; Översti et al. 2019; Lamnidis et al. 2018; Jones et al. 2017; Allentoft et al. 2015; Kashuba et al. 2019), where unrest and warfare were evidently not uncommon elements of life (e.g. Lahelma & Sipilä 2004; Sipilä & Lahelma 2006; Tallavaara & Pesonen 2020; Haak et al. 2008), thus indicating many possibilities for gaps (and perhaps even regressions) in the otherwise gradual development that took place during prehistory.

Culture, mobility and people are intertwined concepts, considering pottery or any other prehistoric artefacts. When pottery is understood as a content and expression of a particular cultural group (tribe, family, a cluster of families or tribes etc), then it is also possible to equal it as people. The reasoning cannot be taken as equalizing pottery with a genetic group of people, but rather with a group of people in space and time, sharing similar kinds of beliefs, needs and material culture reflecting in the art, social construction, burials, housing and artefacts. The existence of these chronological and spatial "packages" of attributes are partly demonstrated by chronological studies. Obviously, the typological constructions are never ready, and the contents can be discussed endlessly. The mobility patterns of pottery by cultural transmission, exogamy, migration, innovation and cultural reproduction, in turn, explain both the spread of pottery among the settlements of the Neolithic groups, but also the isolated – traded or donated – translocated artefacts far from the central clusters of the particular pottery groups.[3]

3.2 ON THE RADIOCARBON METHOD AND ERROR SOURCES IN RADIOCARBON DATING

Radiocarbon dating is a method for determining the age of samples containing carbon (e.g. review by Hajdas 2008). Cosmic rays produce a radioactive isotope of carbon (^{14}C, radiocarbon) within the atmosphere. This is incorporated into living organisms through photosynthesis and the effects of the food consumption chain. When an organism dies, the amount of ^{14}C stored within it starts to diminish according to its half-life – the amount it halved every 5730 years. By measuring the current ^{14}C content, when the half-life and original content are known, the time of the death of the organism can be deduced. ^{14}C is a part of the global carbon cycle, and thus is also eventually transferred into other carbon reservoirs such as oceans. Therefore, ^{14}C method

[3] An example from Neolithic Central European context challenge to look more sharply into this matter also in the eastern Fennoscandian context. In a single and short-lived site, many contemporaneous potteries exist indicating both local and translocal origin (Heitz 2017) referring to movement of the ideas and/or people. This is a matter to think also in the Neolithic of eastern Fennoscandia, where several cases of translocal pots have been found in contemporaneous sites in local contexts, e.g. Corded Ware pot in Lapland (Carpelan 2004 c) and asbestos tempered Late Neolithic sherds in southern Finnish Comb Ware sites (e.g. Vikkula 1981: 69).

is widely applicable, but issues related to the carbon's origin and systematic age shifts (i.e. reservoir effects) need to be considered.

The measurement of radiocarbon/^{14}C in the late 1940's was originally done by beta-counting devices, which measured the beta radiation from decaying ^{14}C atoms in the sample. This method involved using several grams of sample material, which in turn meant that small particles could not be radiocarbon dated. Thus, the sampled material was usually charcoal, bone, or wood, or various other organic substances. A major advance came with the advent of Accelerator Mass Spectrometry (AMS), which uses very small samples compared to traditional radiocarbon dating systems. With the AMS method, the required sample size has been reduced to a few milligrams.

In the prehistoric sites of eastern Fennoscandia, organic materials do not survive very well due to acidity of the soil (e.g. Koivisto 2017: 12). The preservation is better in certain special environments, such as in the thicker cultural layers of towns or village sites from the Historical period. Another special case is that of bogs and other wetlands, where the preservation is generally good, depending on the development and moisture conditions of the bog (see Koivisto 2017). Several Stone Age wooden implements have survived for millennia in such bogs, whereas generally organics are preserved for only hundreds of years in the typical soil environments of the region. Some Stone Age human bone fragments have also survived in graves (Pesonen et al. 2014; Ahola et al. 2016).

The chronology of Early and Middle Neolithic ceramics is based on radiocarbon dates. However, when using radiocarbon dates one must be cautious in interpreting them. There are several error sources that hamper, if not outright hinder, the use of some dates.

3.2.1 THE 'OLD WOOD' EFFECT

Traditionally, eastern Fennoscandian Stone Age sites and artefacts have been radiocarbon dated with charcoal samples derived either from structures at the site (e.g. hearths, pits), from associated cultural layers, or from stratigraphic sections. Charcoal (and wood) itself is a good dating material, and as a terrestrial material it does not suffer from the reservoir effect. On the other hand, old wood, deadwood, or (in the coastal areas) even driftwood may have been used at the time of deposition, and there can be a significant time difference between the death of a tree and the archaeological event. For example, in the Inari region, a single fireplace has produced dates spanning several centuries, with a potential reason being the use of some old wood in the fireplace along with fresh wood (Carpelan 2004 b; but see also Seppälä 2007:85). Based on comparisons between wood/charcoal dates and dates derived from shorter-lived organic materials, it has been suggested that the own age of the Stone Age charcoal samples in Finland is around 40 ± 80 ^{14}C

years (Paper I). Although the mean difference seems to be fairly small, the risk of the own-age effect must be acknowledged when dealing with single datings. The estimate above allows for an effect of about 240 ^{14}C years (within 3σ of confidence); if deadwood was used in fireplaces, the effect can potentially be even larger.

Birch bark tar is a dry-distillation product of birch tree bark. Birch bark grows in yearly layers, together with and attached to the tree ring of that same year. Therefore, it is reasonable to assume that the yearly growth of bark is proportional to the yearly growth of the tree ring. Furthermore, when the tree grows, this pushes the already-grown bark layers farther away from the centre of the tree, causing stretching and thinning of these layers year by year. The tree grows fastest during the first decades of its growth; these years thus produce the thickest sections of bark. When a tree grows old, the bark sections become thinner. Eventually, the bark becomes an admixture of variously aged layers, and thus also of various atmospheric ^{14}C content. For instance, an 85-year-old birch cut in May 2012 yielded a ^{14}C content for its bark of 138 percent of Modern Carbon (pMC), i.e. 1,38 times the year 1950 value (Pesonen et al. 2013). This ^{14}C level corresponds to the atmospheric ^{14}C content for the years 1974-1975 (Levin & Kromer 2004), thus giving an age estimate that is 35-40 years older compared to the felling year. This is a systematic offset, but of the same order compared to the typical statistical uncertainty of a radiocarbon date. If younger trees still within their most extensive growth periods are used to produce the tar, the wider bark layers closer to the felling year would be more dominant, thus yielding smaller own-age effects.

Overall, birch bark and birch bark tar can be considered as very suitable radiocarbon dating materials (e.g. Pesonen 1999 a; Pesonen et al. 2013). Birch bark tar repairs of ceramic vessels provide the best context dating material available to date for those ceramics. Unfortunately, surviving examples of these repairs are very rare in Early and Late Neolithic ceramics. The method has been more commonly used for the Middle Neolithic period, especially in Typical Comb Ware vessels (e.g. Pesonen 1994; 1999 a; 2004).

3.2.2 THE MARINE RESERVOIR EFFECT (MRE)

While charred food crust on vessel surfaces is a contextually very secure dating material, it also contains several potential sources of uncertainties. One of them is connected to the origin of the crust. If it is of marine origin, the dating result potentially carries the so-called reservoir effect, which provides older values for the datings than expected. In the marine conditions of the northern Baltic Sea (between 59° and 66°N latitude), the current average value of the marine reservoir effect (MRE) is estimated as 231±113 years, and in the Arctic Ocean as 370±77 years (CHRONO Marine database; Paper II, Paper IV, Paper

V),[4] arrived at by averaging the identified MRE effects within these areas. The amount of MRE in the Baltic Sea has varied considerably over the Holocene, but its exact values in different eras are not known. One possibility to alleviate this error is to make a correction based on the stable isotope signal ($\delta^{13}C$ or $\delta^{15}N$) in the dated material. The isotopes reflect the marine or terrestrial origin of the food ingredients present in the crust sample, and it is then possible to calculate the amount of the reservoir effect in each sample from its stable carbon or nitrogen isotope value (Paper II; Paper IV; Oinonen et al. 2013 a; Oinonen et al. 2020). It has been determined that isotope values are largely maintained even when the material is heated, thus reflecting the origin of the ingredients in the food crust (Philippsen 2012; 2015; Yoshida et al. 2013; Fernandes et al. 2014).

The most straightforward method of making a marine correction may be complicated by the composition of the crust. Different tissue types may produce different isotopic ratios (Post et al. 2007). In particular, fat tissue seems to have lower $\delta^{13}C$ values compared to muscle tissue, and this may play a role in the lower observed values. On the other hand, it may also be possible that carbon from river inflows ended up in samples of otherwise seemingly fully marine contexts, counter-effecting the MRE or even imposing a freshwater reservoir effect (FRE, see below) on the sample (Philippsen 2013).

The observed difference between the crust stable isotope values (especially $\delta^{15}N$) for the inner and outer surfaces should also be taken into account (e.g. Mökkönen & Nordqvist 2019; also Philippsen 2013), but unfortunately this information is missing from most of the charred crust dates in the available dataset. It is assumed that the main part of the charred crust samples were taken from the inside of the vessels.[5]

3.2.3 THE FRESHWATER RESERVOIR EFFECT (FRE)

Inland water may carry the freshwater reservoir effect (FRE), as has been suggested for many cases in western and eastern Europe (e.g. Fischer & Heinemeier 2003; Philipsen et al. 2010; Philippsen 2013; 2015; Wood et al. 2013; Bonsall et al. 2015; Lillie et al. 2009). FRE originates from old carbon dissolved in running or still water, and thus affects the ^{14}C signal derived from the animals and plants living in lakes and rivers. FRE has often been estimated as having an even larger impact than its marine counterpart; some estimates taken in specific conditions have even produced ages that were hundreds of years too old. This problem is relevant to areas with significant reservoirs of carbonates in surface bedrocks or aquifers. There are abundant carbonate

[4] The measurements of the northern Baltic Sea are listed in Paper IV: Appendix 4.

[5] For example, I myself can never recall taking a charred crust sample from the <u>outside</u> of a vessel wall.

reservoirs in the Baltic Sea area, e.g. in Estonia, Gotland, Öland, and southern Sweden (Lougheed et al. 2013). In contrast, the bedrock of eastern Fennoscandia is practically devoid of carbonates, although in some areas calcite and dolomite exists in significant amounts, which could also affect the intake of radiocarbon into living organisms. Potentially risky areas in this respect include Lake Onega in Karelia, southern Finland, and the lower reach of the River Kemijoki (Tervola area) in southern Lapland, where both nowadays and historically carbonate mineral deposits have been exploited (Fig. 3.1).

In the context of eastern Fennoscandia, the freshwater reservoir effect has been considered only marginally, usually by stating that it is probably of minor relevance because of the lack of these carbonate deposits in the bedrock (e.g. Paper II; also Mökkönen & Nordqvist 2019). The lakes in eastern Fennoscandia are also shallow, and the stability point between dissolved and atmospheric carbon is thus reached more quickly than in deep oceans (e.g. Philippsen 2013).

Zhulnikov et al. (2012) have suggested FRE as a reason for the discrepancy in the Middle and Late Neolithic dates for asbestos and organic tempered ceramics in eastern Fennoscandia. However, the comparison does hold up very well, as most of the charred crust dates are from Finland and many of the charcoal dates are from Russia. The material also includes coastal as well as inland sites, including several sites by a large body of water (Lake Onega), which indeed may be prone to the reservoir effect due to the carbonate deposits in the area. The latter may well be reflected in the radiocarbon dates from the Voynavolok XXVII site, where crust on Voynavolok pottery yielded a radiocarbon date 200-400 years older than the charcoal dates from the housepit wall (Zhulnikov et al. 2012: Table 1). In the coastal/estuarine site of Korvala in Yli-Ii (Oulu), the difference is small, but could indeed reflect marine reservoir offset (Zhulnikov et al. 2012: Tables 2 and 3). The only other comparable pairs of dates are from the inland sites Kuorikkikangas in Posio and Sätös in Outokumpu (Zhulnikov et al. 2012: Tables 2 and 3). In Kuorikkikangas, the crust date is 150-350 radiocarbon years older than the structures of the pithouse – the problem is that the dated Pöljä pottery is not from the pithouse and does not necessarily date the same phase of habitation (Pesonen 1996 d; 2006). In Sätös, the crust dates range roughly from 4540 to 4290 BP, and the charcoal dates from 4380 to 4180 BP, which hardly leaves much space for reservoir effect (Karjalainen 2002; Pesonen 2004). Furthermore, the dates are from two different pithouses at the site (Karjalainen 2002). In sum, the case presented by Zhulnikov et al. (2012) does not prove large scale FRE in eastern Fennoscandia. However, one must still take this effect into account when discussing charred crust dates from the area. In the Tudozero 5 site, on the southern part of Lake Onega, FRE has been estimated to be of no substantial significance (Piezonka et al. 2017).

In addition, the Koivikko site in Kitee must be mentioned in this connection. In an earlier paper (Paper III) we have identified the dated rim sherd (see Luho 1957: 143) as a Sperrings 1 Ware sherd, but Nordqvist & Mökkönen (2016 a) see Pit-Comb Ware characteristics in it. As they note, the date 6117±44 BP (Hela-2953) is old compared to other Pit-Comb Ware charred crust dates. The stable carbon isotope value of the sample is -30,10 ‰, which indicates a freshwater origin. There are examples from Leningrad Oblast where the freshwater reservoir effect is suspected as a reason for very old dates derived from charred crust material (Seitsonen et al. 2016). It is thus possible that FRE issues at least play a part in these areas.

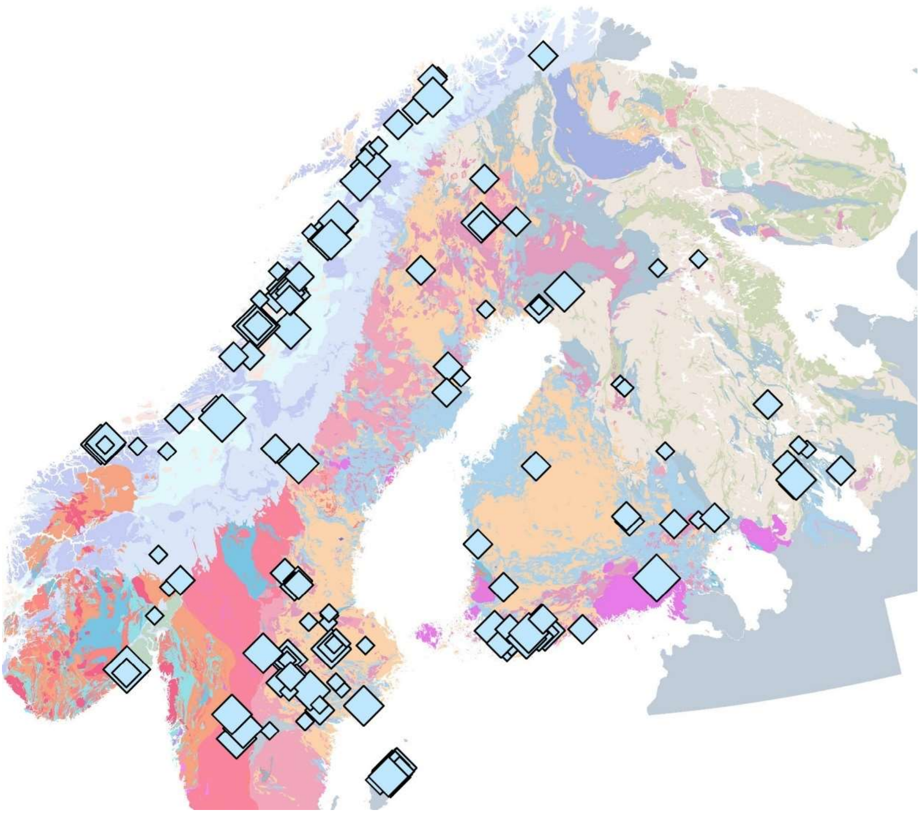

Figure 3.1. The carbonate mineral (calcite and dolomite) deposits in Fennoscandia. Source: Fennoscandian Mineral Deposits application, Geological Survey of Finland: https://gtkdata.gtk.fi/fmd/. Data retrieved 27.3.2020.

3.2.4 REPLACEMENT OF CARBON IN BURNT BONE MATERIAL

Bone material is very rare in the study area and consists almost entirely of burnt bone fragments of hunted prey and fish. In Varanger Fjord, some unburnt seal bones have been dated but are considered to be affected by the marine reservoir effect (Helskog 1980; Skandfer 2009). During the last 10-20 years, burnt bone has also been used for radiocarbon dating with promising results (e.g. Lanting & Brindley 1998; Lanting et al. 2001). Recently the role of fuel, and especially the replacement of carbon in the cremation process, has been debated (Hüls et al. 2010; Van Strydonck et al. 2010; Olsen et al. 2013). It is possible that the radiocarbon signal in burnt bone samples actually represents the wood used in the cremation, which would give the burnt bone dates the same weight as the traditional charcoal dates. On the other hand, the replacement of the animal bone signal by a wood signal would eliminate the problem of the reservoir effect in marine burnt bone samples. If this is true then the burnt bone dates should be quite reliable, and there is no need to make any corrections to them. In one of the original studies, Lanting et al. (2001) compared the quality of the burnt bone dates to charcoal dates from the same contexts. The very good agreement between them might be explained by the integration of charcoal carbon into the bone matrix during the burning process. The burnt bone dating procedure used for the eastern Fennoscandian contexts does not essentially differ from the method presented by Lanting et al. 2001 (see Jungner 2004; Oinonen et al. 2013c).

It has also been speculated that small burnt bone samples may not be suitable for radiocarbon dating, and large pieces (over 2 g) are recommended (Naysmith et al. 2007). Smaller pieces may take in secondary carbonate from rainwater, although this contamination may be eliminated with proper pre-treatment (Boudin et al. 2009). So far there are no specific studies concerning problems in the dating of small pieces of burnt bone in eastern Fennoscandia, but in one case a doubt has arisen over whether using a collection of small pieces, rather than one larger bone, might produce speculative results (Pesonen et al. 2020: 9). The temperature of the cremation also affects the crystallinity of the dated apatite fraction in the bone: if the bone does not burn at a high enough temperature, the apatite is vulnerable to soil contamination and thus yields false dating results (Minami et al. 2019).

3.2.5 THE EFFECT OF LOW AMOUNTS OF COLLAGEN IN BONES

The radiocarbon dating of (unburnt) bones are usually performed on the collagen residue extract. The content and quality of collagen may vary significantly between samples, depending on the original condition of the bone itself and its deposition environment. In addition to preservation problems, the bone may absorb carbon from its surrounding environment, thus giving false dating results (e.g. Scirè Calabrisotto et al. 2013). The soil in eastern Fennoscandia is very acidic, and the level of bone preservation is generally very poor; for example, there are only sporadic finds of human bone from the Stone Age. Most of these are from red ochre burials, where occasional jaw bones and teeth have survived (Ahola et al. 2016). The dating of these specimens has resulted in serious difficulties for their interpretation, as the dates of assumedly Middle Neolithic graves have turned out to be several thousand years younger than expected (e.g. Edgren 1999; Schulz 2006; Mökkönen 2013). The reason for this discrepancy may well lie in the low content and quality of the collagen preserved in these teeth and bone fragments.

3.3 STATISTICAL ANALYSIS OF THE ARCHAEOLOGICAL RADIOCARBON DATES

Bayes' theorem deals with the probability of a particular event using a priori knowledge related to this event. In archaeology, these events may be e.g. the beginning or the end of a period (e.g. Dee et al. 2013), the appearance of an artefact type in relation to natural history (e.g. McColl 2008), or the stratigraphic sequences in an archaeological site (e.g. Bayliss et al. 2015). Similarly, archaeological phases, technological traits, fashions, and "cultures" can be understood as stratigraphical units as well and can thus be tested through Bayesian approaches (e.g. Edinborough et al. 2015). One of the absolute assets of the Bayesian principle is the ease of updating old information in models with new information as they become available.

The basic works that introduced Bayesian inference into archaeological science were conducted by British scholars in 1990's and 2000's (e.g. Buck et al. 1991; Bayliss 2009; 2015; Bronk Ramsey 2009; Edinborough 2009). Since then, the modelling of archaeological radiocarbon dates has become standard procedure in many archaeological projects, including to some extent in eastern Fennoscandia (Oinonen et al. 2013 b; Paper II; Paper III; Paper IV; Paper V), although it is not yet so popular here as in the rest of Europe.

Bayesian inference takes account the archaeological a priori assumptions, which in my case means that the radiocarbon dates of typologically coherent pots form a phase which has a beginning and an end. The underlying assumption is that there are no similar pots that have emerged either in more distant or more recent prehistory, and that there is likewise no replication of forms later in history that could confuse the phase definitions. This is an important prerequisite for the study, and if this is not accepted, there is no sense using Bayesian models. The confidence in single dates must be abandoned, and one must remember that there are potential outliers which can be recognised and rejected from the chronological sequences.

Summed probability distributions (SPDs) of radiocarbon dates are utilised to represent long-term variation in archaeology and paleoenvironmental research. Numerous studies explore developments in population densities through SPD-derived proxies (e.g. Edinborough et al. 2017; Riede 2009; Shennan 2009; Shennan & Edinborough 2017; Tallavaara et al. 2010;

Tallavaara 2015). SPDs are also a practical way to illustrate the variation in one picture and to correlate it with other available proxies. Simply said, SPD is a portrayal of the probability distributions of several radiocarbon dates summed into one graph. In this study, SPD's of the radiocarbon data for the Neolithic in eastern Fennoscandia have been compared with the Bayesian phase model results of the same radiocarbon dates.

The use of summed probability distributions in archaeology has not been accepted as such, and there has been much critique, e.g. claiming that the variation in SPDs largely depends on the behaviour of the calibration curve (e.g. Kerr & McCormick 2014; overview by Williams 2012), and it has also been argued that there is too much statistical noise in any SPD to allow for the true tracking of demographic signals (Contreras & Meadows 2014). As Christopher Bronk Ramsey (2017: 1811) puts it: "In general, there are three main problems with this as an approach: noise due to the limited number of dated samples, noise from the calibration process, and excessive spread due to measurement uncertainty." However, these problems should not be considered as fatal for the approach, as they can be alleviated by utilising a larger number of dates, by creating simulations to understand the effects of the calibration curve, and by reducing the measurement uncertainties, respectively. It has also been suggested that the eastern Fennoscandian radiocarbon data is not adequate for a dates-as-data approach as such and is prone to carry all kinds of biases (Mökkönen 2014). This has been rebutted, however, by showing that the mere possibility of bias does not invalidate the data (Tallavaara et al. 2014b).

4 MATERIALS AND METHODS

4.1 RADIOCARBON DATING MATERIALS IN EASTERN FENNOSCANDIA

Before the AMS-method in radiocarbon dating came into use in eastern Fennoscandia, for the most art only charcoal and wooden samples could be radiocarbon dated. Bone collagen was dated in rare instances if the bone had survived the archaeological deposition process. Only relatively large samples could be dated with the original beta counting method, and thus the available sample materials were limited. With the AMS-method the sample size was in some cases reduced to some milligrams, and a wide variation of archaeologically interesting materials thus came into sphere of radiocarbon dating, including seeds and grains, charred crust, birch bark tar, and also burnt bones.

The archaeological radiocarbon dates utilised in the individual papers of this dissertation were compiled as a database in the Argeopop-project of the University of Helsinki during 2009–2012 and were later supplemented by me through various dating programmes and fieldwork over the ensuing years. The archaeological radiocarbon database has not been published so far (see Pesonen & Sundell 2011), but the earliest radiocarbon dates have been published both in the form of books (Jungner 1979; Jungner & Sonninen 1983; 1989; 1996; 1998; 2004) and a public database (Junno et al. 2015). However, these publications include only the dates measured by the Laboratory of Chronology (former Dating Laboratory) of the Finnish Museum of Natural History / University of Helsinki (Hel- and Hela-dates); the rest have been collected from relevant publications. This implies that the database is by no means all encompassing, although it still covers the important portion of radiocarbon dates from the archaeological contexts in Finland. The radiocarbon dates from neighbouring areas have been collected from the relevant papers. The database includes many archaeological radiocarbon dates that are not relevant to the dissertation's focus on Stone Age studies. The radiocarbon dates connected with any archaeological sites in Finland (prehistoric and historical) and selected Russian and Norwegian radiocarbon dates are summarised in Table 4.1, and the radiocarbon dates elaborated in the individual dissertation papers are listed in Appendix 1. In Chapter 6, some new charred crust and birch bark tar dates are also added to the discussion. All charred crust and birch bark tar dates are listed in Appendix 2. The context dates related to Säräisniemi 1 Ware are listed in Appendix 3.

Table 4.1. Archaeological radiocarbon dates in the database collected by the author, approximately until the end of year 2019.

	Finland	Russia	Norway	Sum
pine and birch bark	26	7		33
birch tar	98	20		118
antler and bone	238	2	1	241
burnt bone	267	17		284
charcoal	1544	58		1602
grain, seed, nut	179	2	16	197
charred crust	290	102	17	409
wood	365	19		384
plaster/mortar	150			150
other organics	26	3		29
iron	7			7
Sum	3190	230	34	3454

4.2 THE RELEVANCE OF RADIOCARBON DATING ERROR SOURCES IN THIS STUDY

Paper I deals mainly with charcoal samples and their validity in creating population proxies through the use of summed probability distribution curves. In this respect, the own age of the charcoal dates could be critical, but as shown the overall effect seems to be 240 calendar years at maximum. This generalization does not of course exclude sporadic cases of deadwood, which can stand several hundred years after the tree's death. On the other hand, all charcoal dates can not be excluded based on sporadic cases. In Papers II-V, several birch bark tar dates are considered, for which the relevance of the material's inner age is very important. The same applies to charred food crust dates in these same papers, where the importance of marine reservoir effect (MRE) on aging the dates is considered a problem, and a method to correct these dates is presented. The sample series also includes several burnt bone dates, which are prone to the same limitations as charcoal dates – if the replacement of carbon during combustion is accepted as a valid theory. The freshwater reservoir effect (FRE) is considered to be of minor importance in eastern Fennoscandia, due to the low frequency of carbonate bedrocks and aquifers. However, so far there are no studies that allow any strong conclusions to be made regarding this issue, although studies towards understanding the FRE in eastern Fennoscandia have recently been started (e.g. Oinonen et al. 2020). There are no unburnt bone samples in my study material, and thus the problem of possibly low amounts of collagen does not play any role. One must remember, however, that some bone dates from Typical Comb Ware cemeteries have yielded anomalous results that may result from this error source.

4.3 BAYESIAN MODELLING OF ARCHAEOLOGICAL DATES

In Papers II-V, the Bayesian modelling was accomplished with Oxcal software (Bronk Ramsey 2009), which is the most popular application for Bayesian modelling in archaeology. In my dissertation the outcome of the analyses helps to organise the chronology of eastern Fennoscandian prehistory by correlating certain ceramic phases with calendar years.

But how true is a radiocarbon date, and are you allowed to "break it down" in order to shape a new truth out of it?

It is known that some radiocarbon dates may be outliers. In an early study on radiocarbon dates, one of every twenty dates (5%) were outliers within a 2σ confidence level (e.g. Bowman 1990: 38). Today, with the advent of the AMS-method, the reliability is better. Radiocarbon dates are probabilities with a normal probability distribution, and sometimes the error margins are larger, sometimes they are smaller, usually depending on the dated material and the measurement method. Moreover, the amount of radiocarbon in the atmosphere has fluctuated over the millennia, implying that when a date is calibrated according to a calibration curve, its posterior probability distribution expands even more, and the normal distribution breaks down (Fig. 4.1). These obstacles can be partially overcome, for example by measuring several samples of the same archaeological context, thus imparting more confidence and reducing the effects of statistical error and the calibration curve. However, there is no way to avoid or alleviate all the natural phenomena that govern the atmospheric ^{14}C content.

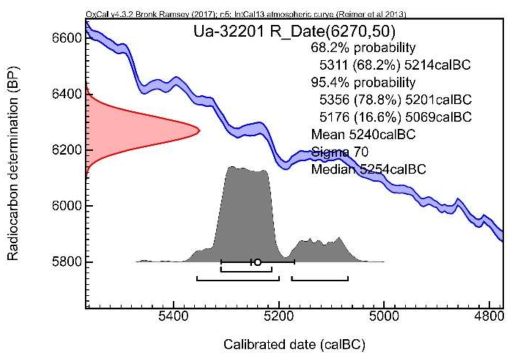

Figure 4.1. An example of the calibration of a radiocarbon date (Ua-32201 from Hakkilan tienhaara site in Vantaa; Leskinen & Pesonen 2008) and the breakdown of probability distribution from the normal distribution (vertical scale) to the splintered distribution (horizontal scale). Calibration with Oxcal v. 4.3 and IntCal13 atmospheric curve (Bronk Ramsey 2009; Reimer et al. 2013).

Modelling an archaeological phase in Oxcal includes defining starting and ending boundaries for the phase and incorporating the relevant (MRE/FRE-corrected) radiocarbon dates into the model. In an example of a phase model (Fig. 4.2), the effect of modelling the dates inside a phase is seen as reduced probability margins, especially in the samples with large error margins, typically beta-counted charcoal dates.

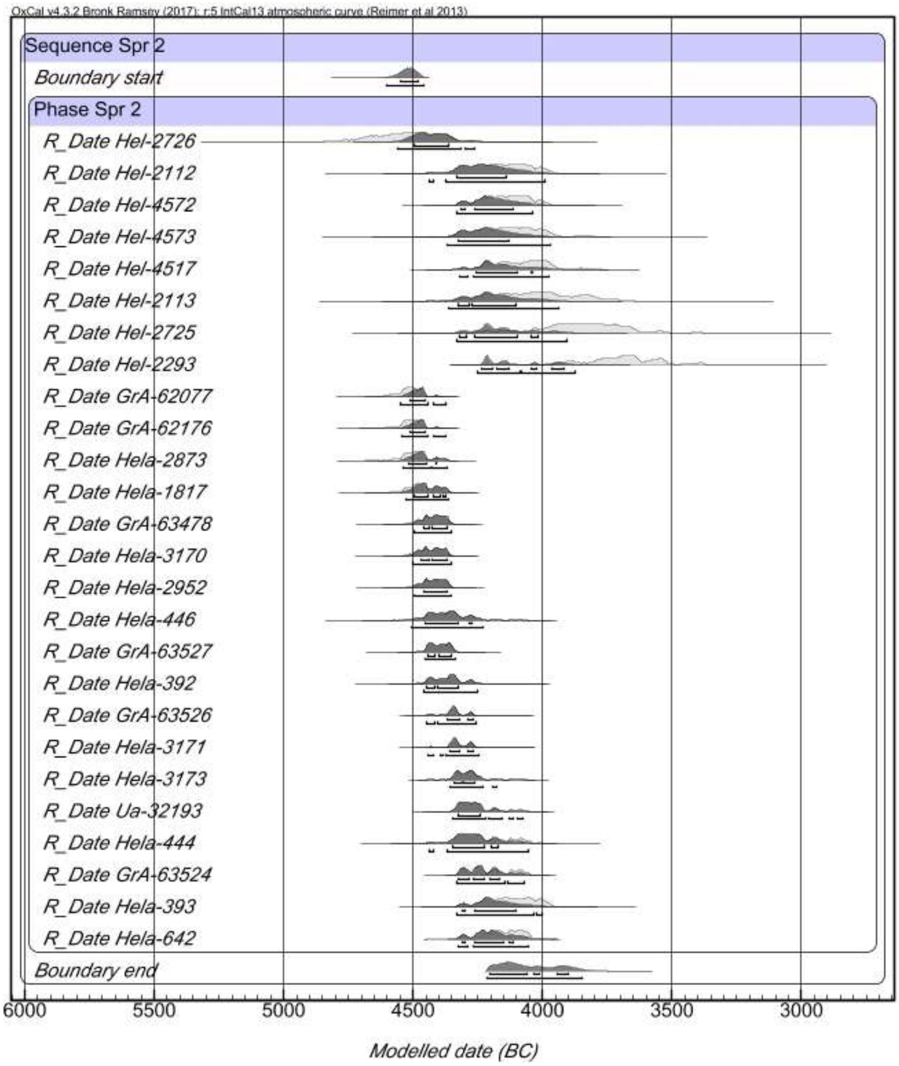

Figure 4.2. An example of a modelled phase, for Sperrings 2 Ware radiocarbon dates from eastern Fennoscandia; the first eight dates are charcoal dates, and the rest are charred crust dates, MRE corrected when applicable. The light grey colour indicates individual probability distributions, and the dark grey colour indicates the posterior probability distributions produced by the model. The starting and ending boundaries are the actual outcome of the procedure. The original and corrected dates are listed in Appendix 1. See also Fig. 4.3.

4.4 MARINE RESERVOIR EFFECT CORRECTION

The amount of marine reservoir effect (MRE) within the Baltic Sea varies according to the geographical origin of the carbon, from ca. 400 radiocarbon years at the Danish Straits to ca. 25–50 radiocarbon years at the bottom of the Bothnian Bay (Lougheed et al. 2013). In the northern Baltic Sea (the Gulf of Finland, the Gulf of Bothnia, and the Bothnian Bay), the current average value of the marine reservoir effect (MRE) is estimated as 231±113 radiocarbon years (N=8, CHRONO Marine database, http://calib.org/marine/).[6] The large amount of uncertainty reflects the systematically decreasing trend between 59° and 66°N latitudes towards the Bothnian Bay. In Papers II, IV, and V this systematic offset is estimated according to a correction based on the stable carbon isotope signal $\delta^{13}C$ in the dated material. This isotopic ratio reflects the proportion of marine and terrestrial origins of the charred crust sample, making it possible to scale down the maximal reservoir effect in each sample based on this data (Paper II; Paper IV; Oinonen et al. 2013 a).

Generally, the average value of $\delta^{13}C$ for the terrestrial samples in the food residue is about -26‰ (Fischer & Heinemeier 2003; Paper II). In Paper II, the maximum 100% marine isotopic signature was determined to be -19.3 ± 2.0‰. However, both isotopic baseline values and RE values vary within the Baltic Sea. In particular, the isotopic signatures are different for marine animals on both sides of the Quark (a strait between the Bothnian Bay and the Bothnian Sea), and RE gradually increases towards the Danish Straits due to the influence of the Atlantic. Recently, more marine isotopic data have been produced (Torniainen et al. 2017; Etu-Sihvola et al. 2019). As a result of this new data, an extreme marine isotopic value for the Baltic Sea can be considered to be even higher: perhaps as high as -15.9 ± 2.0 ‰. A sensitivity analysis using this new value was performed in Paper IV, however it revealed only minor changes in the modelled boundary values. The limited extent of this effect is partly due to large range of uncertainties adopted for both RE and the isotopic extremes. This is justified, however, as our knowledge of both factors is still incomplete.

To date, there have been no pairwise marine and terrestrial sample comparison programs in the research area, which would help to cross check the marine reservoir effect and to correct the procedure explained in Papers II and IV. Such approaches would greatly facilitate chronological studies in eastern Fennoscandia, as they have already helped to understand the degree

[6] In Paper II, the MRE was defined as 279±77 years according to the values available at that time for the entire Baltic Sea basin. During the writing of Paper IV it became possible to select only the eight northernmost datapoints, which better represent the conditions in eastern Fennoscandia, thanks to new measurements by Lougheed et al. (2013). The northern Baltic Sea data is from studies by Olsson (1980) and Lougheed et al. (2013).

of reservoir effect in various other areas of the world (e.g. Ascough et al. 2005; Reimer 2014; Cook et al. 2015; Edinborough et al. 2016).

4.5 VISUALISATION: SUMMED PROBABILITY DISTRIBUTIONS AND KERNEL DENSITY ESTIMATES

One way to produce a visual representation of the summed radiocarbon dates and reduce the statistical noise is to use kernel density estimate (KDE) models and plots (Bronk Ramsey 2017). While modelling with KDE functions is surely a future prospect for the material used in this dissertation, KDE is here introduced only as an example plot in Fig. 4.3. In eastern Fennoscandia, kernel density estimation has been used to smooth e.g. the temporal frequency distributions of dated sites (Tallavaara & Pesonen 2020; Jörgensen et al. 2020).

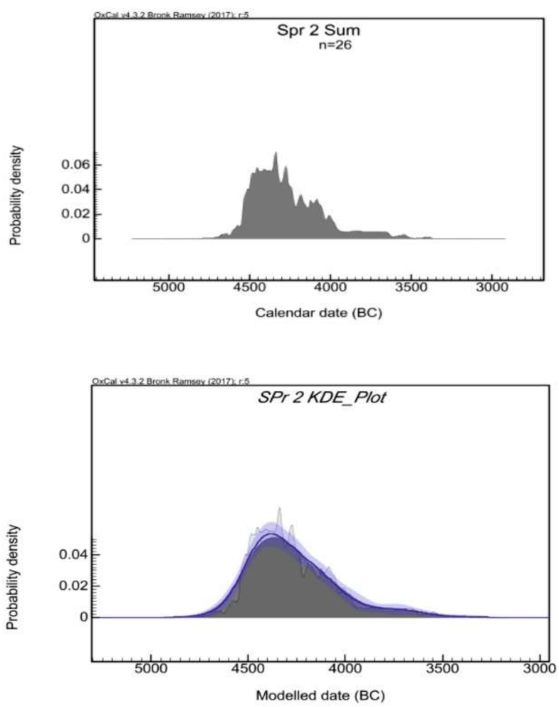

Figure 4.3. An example of different ways of presenting summed probability distributions. On top, the summed probability distribution of Sperrings 2 Ware context radiocarbon dates (the same as in Fig. 4.3), and below the kernel density plot of the same radiocarbon dates. The relevant charred crust dates are MRE corrected according to the procedure explained in Chapter 4.4. The original dates are listed in Appendix 1.

5 RESULTS

The technical results from the Papers I-V are presented in this chapter, in the order of publication (sections 5.1.-5.5) and are then summarized in the last section (section 5.6). From a practical perspective, this chapter also includes a short summary of each paper that hopefully helps the reader follow the discussion more easily, without a need to check the results from the original papers constantly.

5.1 THE RADIOCARBON CORPUS OF EASTERN FENNOSCANDIA (PAPER I)

The radiocarbon dates for eastern Fennoscandia, and Finland in particular, have been accumulated since the 1960's. The majority of radiocarbon dates for the Early, Middle, and Late Neolithic in eastern Fennoscandia are of charcoal origin, and many chronologies still rely largely on these charcoal dates. In Paper I we explored this corpus of Finnish radiocarbon dates in order to find out whether there was any bias or patterning present in the material. The focus of the paper was on the suitability of these radiocarbon dates for the dates-as-data approach employed in the parallel paper exploring the population history of eastern Fennoscandia (Tallavaara et al. 2010). 2565 individual radiocarbon dates were analysed in Paper I (Fig. 5.1). The possible biasing patterns were further reduced in the latter paper by binning radiocarbon dates from the same sites into clusters of 200 years and using a Ceramic Site Frequency Index (CSF-Index) as an alternative proxy for the prehistoric population curve in Finland (Tallavaara et al. 2010).

Our study showed that the 5000 BP maximum and other features in the summed probability distributions (a decline after the maximum towards 3400 BP, a rise through the Metal Ages with a maximum around 2000-1800 BP; cf. Fig. 5.1) reflect the basic archaeological fieldwork results in Finland, independent of special research interests. The single radiocarbon dates published by the National Board of Antiquities (now the Finnish Heritage Agency), mainly from rescue excavations, and to a certain extent the smaller data subsets as well, yielded more-or-less similar date distributions as the total data set, with the local maximum around 5000 BP. The same trends are also visible in the distribution patterns of the radiocarbon dates made in different decades. The robust 5000 BP maximum coincides with Typical Comb Ware's dominance in the archaeological record, and this fact has aroused suspicion of its biasing factor in the observations (e.g. Mökkönen 2011a: 64-65; 2014; Nordqvist 2018: 99). However, the peak period is also seen in other proxies. The number of radiocarbon dates is parallel with the Ceramic Frequency Index, which is an independent variable showing the importance of a particular phase: more sites produce more dates (cf. Tallavaara et al. 2010: Fig. 2). The same peak is visible in the number of dated shoreline settlement sites on the Ostrobothian coast (Tallavaara & Pesonen 2020: Fig. 4).

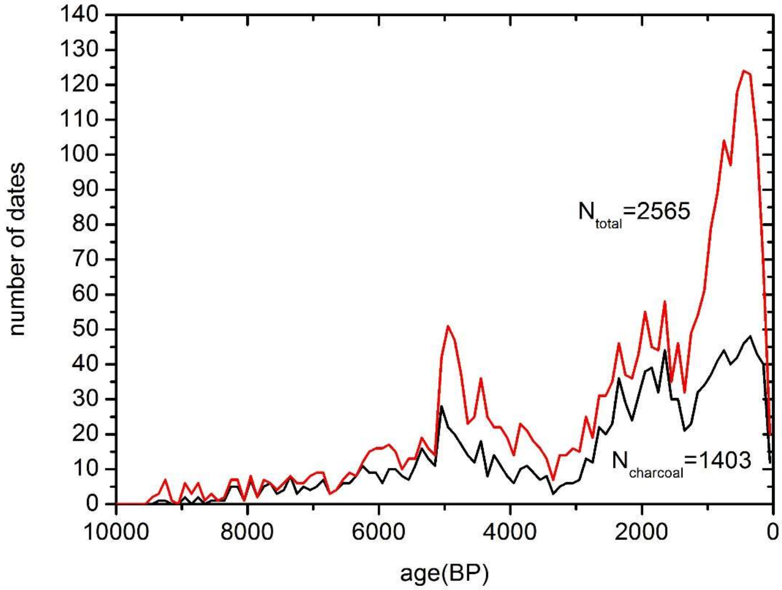

Figure 5.1. Comparison of the temporal distributions of all the ^{14}C dates and the dates obtained from charcoal samples. Reproduced from Paper I: Fig. 2.

No biasing research patterns were detected in our original study, except for the "Early in the North" project with its intrinsic geographical focus on the north. While research biases cannot be totally ruled out, they do not represent a major disadvantage in the current study, as the Bayesian models and the summed probability distributions are presented only phase-wise, not as continuous demographic curves. Nevertheless, while the biasing problems are acknowledged, similar peaks and fluctuations are also present in other studies on other periods and other parts of the world, illustrating the dynamic nature of the human population (e.g. Gamble et al. 2005; Shennan & Edinborough 2007; Fiedel & Kuzmin 2007; Collard et al. 2010). These are not only due to the effects of archaeological visibility, research interests, calibration curves, or forest-fires (discussion in Mökkönen 2014; Tallavaara et al. 2014b). Moreover, in the case of critiques of quantitative approaches, it would be optimal if these efforts would also aim to provide estimations of the magnitude of the assumed biasing effects.

In the paper, taphonomic problems relating to sample degradation are also explored and material-dependent (if any) taphonomic correction procedures are suggested, in place of using a single all-purpose solution based on radiocarbon data derived from volcanic deposits, as has been previously suggested (Surovell & Brantingham 2007; Surovell et al. 2009).

5.2 EARLY NEOLITHIC POTTERY AND THE METHOD FOR MARINE RESERVOIR EFFECT CORRECTION (PAPER II)

In Paper II, Early Neolithic pottery styles are taken under consideration. These include Säräisniemi 1, Sperrings 1, and Sperrings 2 wares in eastern Fennoscandia. In the paper, only charred crust and birch bark tar dates taken directly from the pots are used, and no context dates are considered. The data includes 56 radiocarbon dates from Finland, Russia, and Norway. In this case, two types of Oxcal-models were used: a single-phase model (the model preferred in later studies, Papers III-V) and a two-phase model, the latter only regarding the assumedly continuous ceramic styles Sperrings 1 and 2. The marine reservoir correction process is explained in Chapter 4.6. The study area was divided into northern and southern parts by an arbitrary border drawn between the southern part of the White Sea and Middle Ostrobothnia, in order to study possible differences between the northern and southern environments of the area (Fig. 5.2).

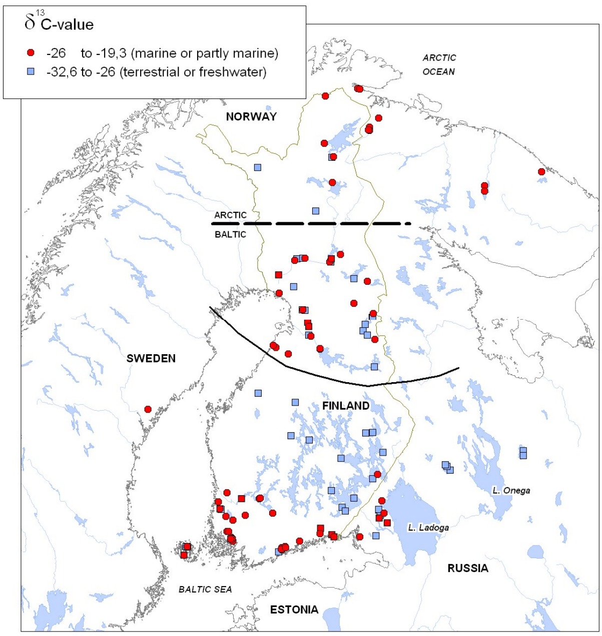

Figure 5.2. Charred crust and δ^{13}C values of Neolithic pottery in eastern Fennoscandia (data until c. 2010). The dashed line marks the border between the Baltic and Arctic reservoir correction, ~67^{0}N. Reproduced from Paper II: Fig. 3.

In the northern part of the research area - in Lapland, coastal Arctic Norway, and northeastern Russia - the first appearance of ceramics is represented by Säräisniemi 1 Ware. The uncorrected results for the beginning and the end of this era are 5365 ± 145 and 4560 ± 85 calBC, respectively, with the earliest examples deriving from the Varangian coast in the Arctic Ocean and along the Pasvik River on the Russian-Norwegian border, as well as from the Kalmozero 11 site in Russian Karelia. Reservoir correction produces later boundaries for the Säräisniemi 1 ceramics, with the beginning and the end of the era being 5190 ± 100 and 4455 ± 110 calBC, respectively. In this case, the reservoir age correction made the dataset more consistent, and even the outlier probability for one of the samples was markedly reduced. It seems that the Norwegian coastal crust dates are quite heavily affected by old carbon, probably because of the marine food ingredients in the charred crusts (e.g. seal, saltwater fish, blubber). The δ^{13}C-values of the Arctic coast vary between -21,2‰ and -24,4‰, well above the typical terrestrial or freshwater values.

Sperrings 1 and 2 ceramics appear both in the southern and northern research areas, but Sperrings 2 dates were available only for the southern part, which meant that the two-phase model could be run only for the latter area. The northern area had only six Sperrings 1 dates, and the results indicate that the style arrived there quite late (4860 ± 160 calBC), while its origins lie in the southern regions almost 300 years earlier (5155 ± 65 calBC). The results indicate a gradual spreading of Sperrings 1 ceramics to the more northern areas of eastern Fennoscandia, where its distribution area finally overlapped with the distribution area of Säräisniemi 1 ceramics; a hybrid form is found in the contact area (Torvinen 2000: Figure 2). Within the two-phase model, the boundary between the Sperrings 1 and 2 styles is located at 4400±30 calBC, and Sperrings 2 Ware production ends already by 4175 ± 95 calBC. In the north, where the two-phase model could not be used, the Sperrings 1 Ware end boundary lies at 4505±160 calBC, indicating a fairly short time-period for the Sperrings Wares in the north.

The principal value of this early paper was to study the marine reservoir effect and to develop a method to evaluate its effect on radiocarbon dates. This method was found to be reliable and was used (with slight modifications) in the later studies (Papers III-V).

5.3 THE TIMING OF THE VUOKSI CATASTROPHE AND THE CULTURAL SUCCESSION IN EASTERN FINLAND (PAPER III)

”The cause must be prior to the effect” (Hume 1740) was the leading thought when writing Paper III. In this paper we evaluated the radiocarbon dates in Early Asbestos Ware and Typical Comb Ware contexts in eastern Finland, and then compared those with the dates connected to the River Vuoksi breakthrough. In addition, the effect of this massive natural catastrophe on the ecology of the societies was considered and the discontinuity in ceramic technology and raw-material acquisition was discussed.[7]

The background of the study was the massive bursting of Ancient Lake Saimaa, which led to the formation of the River Vuoksi in the late Holocene. This phenomenon had been earlier dated according to some organic remains left under the alluvial layers near the breakthrough site of Vuoksi in Imatra, in addition to several palynological dates connected to the breakthrough (e.g. Saarnisto 1970). The birth of the River Vuoksi led to the permanent lowering of the lake level, which has been further lowered during the late Holocene. The former shores of Ancient Lake Saimaa are now several metres higher than the present lake level (e.g. Hellaakoski 1922; Saarnisto 1970). In the paper, the archaeological sites above and below the level of Ancient Lake Saimaa were evaluated, and this information was used as *a priori* information when organising the dates into two classes: 1) before, and 2) after the Vuoksi breakthrough. Accordingly, a model was created in which the timing of the Vuoksi breakthrough was considered to be defined by the boundary between these date classes. This timing, with a 95,4% credibility interval, is 3955–3810 calBC (mean value of 3890 ± 40 calBC), whereas the earlier estimates for the event vary between ca. 4100 and 3700 calBC (Alenius et al. 2008; Delusin & Donner 1995; Jussila 1999; Mökkönen 2011b; Pajunen 2005; Pesonen 1996 a; 1996 b; Saarnisto 1970; 2008; Takala & Sirviö 2003).

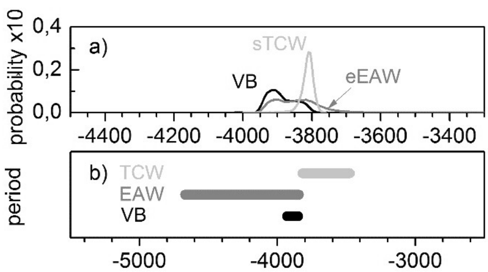

Figure 5.3. a) Posterior calendar year probabilities of the events studied in Paper III: Vuoksi breakthrough (VB), end of Early Asbestos Ware (eEAW), and start of Typical Comb Ware (sTCW). b) Time periods for VB, EAW, and TCW based on boundary mean values. Reproduced from Paper III: Fig. 4 a-b.

We also wanted to model the chronologies for the two essential archaeological features connected to the time of the Vuoksi breakthrough: the presence of Early Asbestos Ware and Typical Comb Ware. The first of these is found mainly in eastern Finland, while the latter has a more even distribution throughout the southern part of eastern Fennoscandia (see Chapter 2). Early Asbestos Ware was modelled to date to 4665–3850 calBC, and Typical Comb Ware to 3815–3475 calBC (mean values; Table 5.1). The material also includes

[7] The critique directed specifically at the ecology part (Mökkönen & Nordqvist 2014) would require a thorough answer and another study, which however is not critically important to the main subject of this dissertation.

context dates (charcoal, birch bark pitch ["chewing gum"] and burnt bone) in addition to direct charred crust and birch bark tar dates from the ceramics. The most interesting results were obtained when comparing the calendar year posterior probability of the events. In this way we established the most probable sequence of events, where the Vuoksi breakthrough preceded the end of Early Asbestos Ware, which in turn preceded the start of Typical Comb Ware; according to this model, there is some overlap between the pottery styles (Fig. 5.3).

5.4 THE CHRONOLOGY OF JÄKÄRLÄ WARE AND OTHER EARLY AND MIDDLE NEOLITHIC POTTERY TYPES (PAPER IV)

In this paper the focus is on the chronology of southwestern Finnish Jäkärlä Ware, but other relevant ceramic groups are examined as well, including Sperrings 1 and 2 Wares, Typical Comb Ware, and Late Comb Ware (Uskela Ware). Regarding Sperrings 1 and 2 ceramics, this paper is an update to the chronology presented in Paper II, and for Typical Comb Ware it is an update to Paper III. Jäkärlä Ware has only ca. 50 find-places in Finland, many of them only sporadically investigated; as a result, the dating series from two sites, Sauvo Nummenharju and Kemiönsaari Nöjis, have dominated the chronology of this group, giving it a surprisingly long lifespan (1500 radiocarbon years; e.g. Meinander 1971; Asplund 1995). With the help of several new radiocarbon dates from charred crust and burnt bone, we were able to demonstrate that Jäkärlä Ware was in fact a short-lived phenomenon situated between the domains of Sperrings 2 and Typical Comb Ware, with a chronological overlap with the latter (cf. Fig. 5.4). In addition, the new (and shorter) chronology fits better with the shore-line chronology of southwestern Finland.

In this paper, all the available radiocarbon dates connected with the ceramic groups mentioned were evaluated, in contrast with Paper II, where only charred crust and birch bark tar dates were considered. However, after this evaluation, only the modelled results from direct crust and birch bark tar dates are recommended, because of the various problems with the context dates and other associated materials. For the charred crust dates, the marine reservoir effect correction procedure explained in Paper II was applied, but with a newly estimated reservoir age value obtained for the Baltic Sea (Lougheed et al. 2013). The maximum effect of the sensitivity analysis equated to a 95-year difference for the start boundary of Late Comb Ware, illustrating the effect of several very high marine signals in the crust samples for this pottery type. Overall, the studies demonstrate a need to further explore the isotopic and MRE history of the Baltic Sea in order to perform local correction estimations for charred crust (and bone) dates (Torniainen et al. 2017; Oinonen et al. 2020).

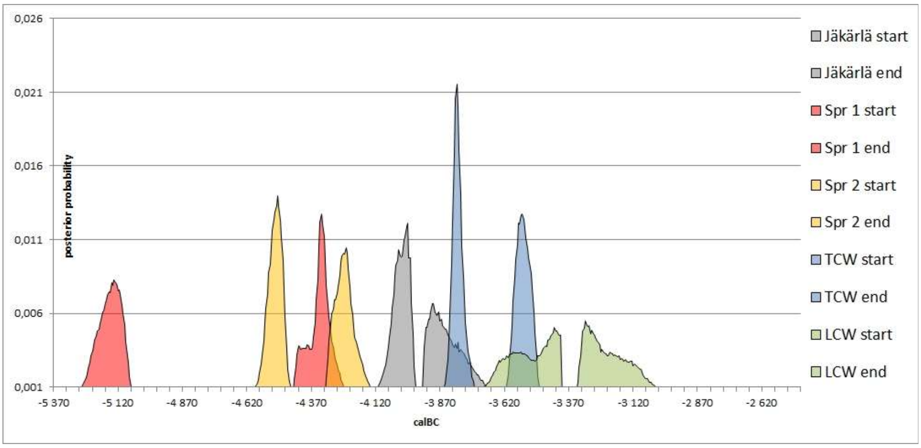

Figure 5.4. The posterior probability distributions for the starting and ending boundaries of each ceramic group. The distributions are from the Bayesian model runs with crust and birch bark tar datings, with reservoir correction applied. Reproduced from Paper IV: Fig. 3.

The modelling runs assigned different timeframes to Jäkärlä Ware, depending on the selection of the samples. For the charred crust dates only (there are no birch bark tar dates for Jäkärlä Ware), a very narrow time period was established for this ceramic type, i.e. 4030–3830 calBC (mean values of start and end boundaries). The chronological position of Jäkärlä Ware at the turn of the 4th and 3rd Millennium calBC puts an end to the speculations linking Jäkärlä Ware to Late Comb Ware or Pyheensilta Ware, both of which are much later traditions in Finnish prehistory.

For Sperrings 1 and 2 Wares, we arrived at values of 5155–4335 calBC and 4510–4225 calBC, respectively. Both of these values were derived from models run only on charred crust and birch bark tar dates. The addition of several new dates for these ceramics, published after Paper II, changed these boundaries only slightly. Perhaps the most significant difference lies in the transformation period between Sperrings 1 and 2 Wares, which now seems to be overlapping strongly. The new dates push the end of Sperrings 1 Ware towards 4335±50 calBC, and the beginning of Sperrings 2 Ware to 4510±40 calBC. The chronological overlap indicates a slow transformation. However, the addition of more dates and a closer look at the typology of the Sperrings ceramics is necessary in order to better understand the development of these pottery styles.

There are almost 200 direct charred crust and birch bark tar radiocarbon dates from Typical Comb Ware, which is far more than any other ceramic group in eastern Fennoscandian prehistory. The large number of dates provides a concise posterior result for the model, which according to crust and birch bark tar dates is 3800–3545 calBC. In southwestern Finland, the smaller number of dates equates to a longer span of time, with crust and birch bark tar dates at ca. 3840–3440 calBC, thus suggesting a short overlapping period between Jäkärlä Ware and Typical Comb Ware in southwestern Finland. This is further illustrated by single statistically overlapping radiocarbon dates on Jäkärlä Ware and Typical Comb Ware from the same site in this area.[8]

The beginning of Late Comb Ware is fairly concisely defined, regardless of the dating material, though the charred crust and birch bark tar date set gives a ca. 100 years younger start for the style than the set with all dated materials. The whole sequence is dated to ca. 3540–3195 calBC according to the model. Interestingly, the beginning of Late Comb Ware and the end of Typical Comb Ware is modelled almost exactly to same date. This indicates that the styles followed each other. Taking into account the sensitivity analysis with an alternative 100% marine limit as explained above, the span of Late Comb Ware would be ca. 3635–3165 calBC. The previous observations of a strong chronological overlap between Typical and Late Comb Wares (Leskinen 2003; Leskinen & Pesonen 2008) disappears in the process of marine reservoir correction, thus providing more cohesion for their typo-chronological positions and the mutual relationship of these two ceramic styles.

5.5 CORDED WARE CHRONOLOGY IN THE PREHISTORY OF FINLAND (PAPER V)

This paper reviews new data on Corded Ware chronology; it is an extension of an earlier paper concentrating on the geochemical provenance investigation of Corded Ware pottery in Finland, Sweden, and Estonia (Holmqvist et al. 2018). Currently, there are 17 radiocarbon dates connected to Corded Ware in Finland, with the older ones being context dates from Corded Ware graves. Only the newer dates are either burnt bone context dates or direct charred crust dates on pottery. Because of the effects of some old context dates, the whole sequence of Corded Ware in Finland has been dated as beginning already in 3200 calBC, which is fairly early compared to Central European, Baltic, or Scandinavian dates (e.g. Mökkönen 2011a: 17; Nordqvist 2016).

In this paper, the models were run with three different strategies: 1) whole dataset, 2) whole dataset but with one outlier (Hel-1006) excluded, and 3) charred crust and burnt bone dates. It is remarkable that the only important change in modelling came with the exclusion of one particular outlier; otherwise, there was no significant difference between the results for the whole dataset and the crust/burnt bone selection. There are fairly long tails in the summed probability distribution of Corded Ware dates, which are however quite insignificant in the bigger picture. A timeframe of 2900–2200 calBC is suggested for Corded Ware in Finland, which is somewhat in accordance with the pan-European context of the Corded Ware phenomenon.

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[8] The Mynämäki Aisti site: Jäkärlä sherd date 5055±41 BP (Hela-3076), and Typical Comb Ware sherd date 5071±42 BP, MRE corrected 5006±53 BP (Hela-3077); see Appendix I.

The beginning of Corded Ware settles quite neatly to 2900 calBC. This is a bit early in comparison to the other European dates, but there are also discrepancies in the wider European Corded Ware chronology that allow for the acceptance of this dating, rather than trying to fit it into the existing chronology by force (Furholt 2003; Włodarczak 2009; Olalde et al. 2018; Piličiauskas 2018; Brozio 2018; Sjögren et al. 2016). The end point of 2200 calBC is late considering the chronology of Corded Ware on the European continent. However, in the "local" eastern Baltic Sea area context, where the late survival of Corded Ware is suggested (Nordqvist 2016; 2018; also Lõugas et al. 2007), the difference is only minor.

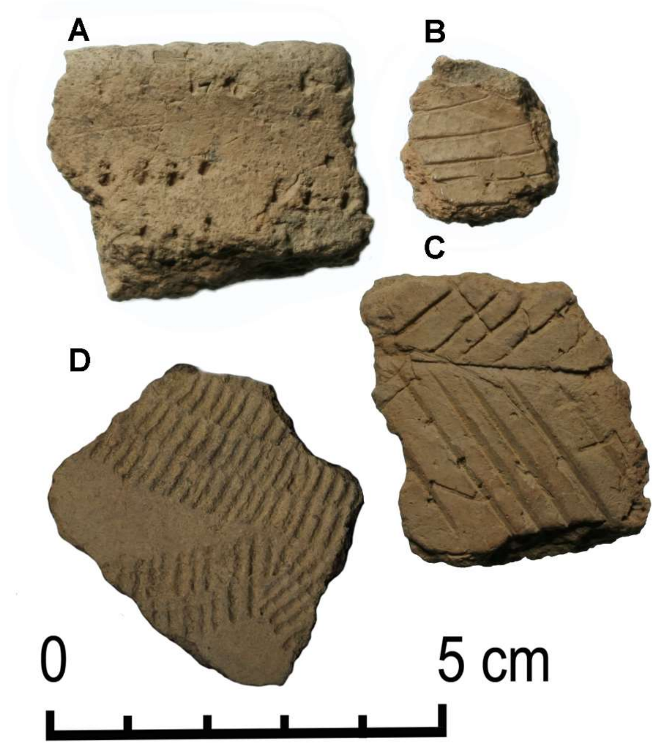

Figure 5.5. Corded Ware sherds, manufactured in coastal Finland, crust-dated to 2880–2600 calBC (A=KM 15329:132 found in Virolahti Mattila VPK), 2900–2680 calBC (B=KM 22004:6006 from Porvoo Böle), and 2480–2300 calBC (C=KM 16288:16 from Espoo Mäntymäki); and in southern Sweden, dated to 2880-2670 calBC (D=SHM 22057 1089883, from Fjälkestad Rötved). Photo: P. Pesonen, Å. Larsson & E. Holmqvist. Reproduced from Paper V: Fig. 4.

5.6 RESULTS SUMMARY

Main results:

1. The evaluation of the Finnish radiocarbon date material shows its utility for summed probability distributions (and demographic curves). This result is

manifested in a number of publications (e.g. Tallavaara et al. 2010; Tallavaara & Seppä 2012; Tallavaara et al. 2014a; Tallavaara 2015; Tallavaara & Pesonen 2020), but the solid reliability of these studies also imparts confidence in the use of these radiocarbon dates in the future studies.

2. The Bayesian modelling of the radiocarbon (or any) dates provides a statistically coherent method to obtain chronological information. In this dissertation the method has been used for several ceramic types (Papers II–V), and for one natural event (Paper III), in order to establish their time spectra.

3. The application of marine reservoir effect correction as developed in Paper II is necessary in situations where no other means for estimating the amount of reservoir effect (e.g. pairwise comparisons) are available, as in the context of eastern Fennoscandian prehistory. This method is based on the $\delta^{13}C$ signature of the charred crust (or bone) radiocarbon sample, which is interpreted as marine when it is over -26‰ and terrestrial/freshwater when under this value. We have used -19.3±2.0 ‰ as an indication of the full marine composition of a sample, but also experimented with a higher value of -15.9±2.0 ‰. The amount of marine composition is calculated arithmetically between 100% marine and 100% terrestrial values according to the $\delta^{13}C$ signature of the sample.

4. While also experimenting with whole radiocarbon datasets, all of the papers came to the conclusion that the use of (MRE corrected) charred crust and birch bark tar direct dates form the most reliable basis for chronological models of pottery styles. Burnt bone context dates were only allowed in the suggested models for Early Asbestos Ware and Corded Ware, and charcoal dates were only included for Early Asbestos Ware. This is due to the small amount of charred crust and birch bark tar dates associated with these potteries.

5. Early Neolithic (Table 5.1). The charred crust dates of Säräisniemi 1 Ware in Norway display a strong marine component. Following MRE correction, these dates appear as much as 200 years younger than without correction. In Paper II, Säräisniemi 1 Ware is thus dated to 5190–4455 calBC. As expected, the earliest Sperrings 1 dates come from northwestern Russia. With the MRE correction, Sperrings 1 Ware is dated to 5155–4335 calBC in Paper IV. With the current knowledge and interpretation of Sperrings pottery, Sperrings 2 Ware is dated to 4510–4225 calBC in Paper IV, i.e. partly overlapping chronologically with Sperrings 1 Ware. The traditional radiocarbon dates from Jäkärlä have a long chronological spread, spanning almost 1500 radiocarbon years. However, in Paper IV the charred crust date model gives a much shorter timeframe for Jäkärlä Ware, between 4030–3830 calBC. Early Asbestos Ware includes two variants, of which the first could be described as an asbestos tempered variant of Sperrings 2 Ware, and the other is called Kaunissaari

Ware. These variants are not distinguished from each other in Paper III, and this combined Early Asbestos Ware is dated to 4670–3845 calBC.

6. Middle Neolithic (Table 5.1). The archaeological visibility of Typical Comb Ware is shown in the number of radiocarbon dates, which is further emphasized by the fact that Typical Comb Ware vessels have birch bark tar repairs far more often than any other types of pottery. Typical Comb Ware is dated to 3820–3475 calBC in Paper III, and in Paper IV to 3800–3545 calBC; this difference is within the statistical error margins. The charred crust carbon isotope values of Late Comb Ware display a strong marine tendency, and the radiocarbon dates are correspondingly heavily affected by MRE. With the necessary reservoir effect correction, Late Comb Ware is dated much younger than without these corrections, which also removes the overlap "problem" between Typical Comb Ware and Late Comb Ware. The latter is dated by charred crust and birch bark to 3540–3195 calBC.

7. Late Neolithic Corded Ware culture is an almost pan-European phenomenon, which has a strong effect on our understanding of the later development of European prehistory, for example in terms of agriculture and animal husbandry. Corded Ware pots rarely have charred crust preserved, which usually requires the use of other dating materials in the chronological models. With charred crust and burnt bone dates in Finland, Corded Ware is dated to 2900–2200 calBC (Table 5.1).

8. In the future, the growing corpus of isotopic signatures and MREs from the Baltic Sea area will provide better opportunities to further develop the MRE correction procedure.

Table 5.1. Combined results table of the analyses in Papers II-V. The models used are so-called single-phase models (see Paper II: Tab. 2). The first and last values in a given cell are the starting boundary and the ending boundary, respectively, while "xxxx" denotes that the boundary could not be solved. OxCal 4.2 was used in the analysis (Bronk Ramsey 2009), with the calibration curve IntCal 13 (Reimer et al. 2013). Those values marked in bold describe the most probable boundaries for the use-period of the given ceramic types. TCW = Typical Comb Ware; CW = Comb Ware.

	Without reservoir correction, mean value (calBC)	Without reservoir correction, 68% HPD region (calBC)	Without reservoir correction, 95% HPD region (calBC)	With reservoir correction, mean value (calBC)	With reservoir correction, 68% HPD region (calBC)	With reservoir correction, 95% HPD region (calBC)	Paper	Notes
Säräisniemi 1 crust and bbt (n= 22)	5365±45 4560±85	5560-5220 4660-4505	5615-5085 4720-4395	**5190±100** **4455±110**	5265-5075 4575-4350	5390-5010 4670-4260	II	
Sperrings 1 / Ka 1:1 all (n=82)	5555±40 4175±45	5590-5515 4243-4155	5620-5490 4325-4080	5560±40 4170±45	5595-5515 4225-4150	5630-5490 4235-4075	IV	
Sperrings 1 / Ka 1:1 crust and bbt (n=40)	5160±50 4340±50	5195-5095 4425-4295	5260-5070 4435-4255	**5155±50** **4335±50**	5190-5095 4405-4285	5250-5070 4435-4255	IV	
Sperrings 2 / Ka 1:2 all (n=26)	4525±35 4075±110	4550-4485 4215-3915	4460-4525 4225-3865	4525±40 4050±110	4550-4485 4205-3900	4605-4460 4220-3855	IV	
Sperrings 2 / Ka 1:2 crust and bbt (n=18)	4510±35 4240±40	4540-4475 4290-4210	4556-4420 4353-4101	**4510±40** **4225±50**	4540-4475 4290-4200	4600-4415 4310-4125	IV	
Jäkärlä class 1 dates (n=15)	4070±50 3550±60	4090-4020 3620-3525	4180-3995 3635-3425	4055±50 3550±65	4080-4000 3620-3525	4160-3980 3635-3420	IV	
Jäkärlä class 2 dates (n=30)	4700±105 3355±105	4780-4575 3475-3285	4910-4500 3550-3135	4700±110 3350±110	4780-4575 3475-3280	4915-4505 3550-3120	IV	Hela-3075 left out
Jäkärlä only crust (n=9)	4035±40 3885±55	4055-3990 3945-3870	4105-3975 3955-3770	**4030±50** **3830±80**	4050-3980 3930-3790	4120-3960 3950-3675	IV	Hela-3075 left out
Early Asbestos Ware, all (n= 23)	**4670±55** **3845±60**	4720-4605 3930-3795	4780-4560 3955-3725				III	no correction used
TCW all (n=188)	3930±30 3335±20	3950-3905 3345-3325	3970-3880 3355-3310	3920±30 3345±45	3950-3895 3350-3320	3965-xxxx 3475-3300	IV	
TCW crust and birch bark tar (n=72)	3825±25 3550±30	3840-3800 3580-3525	3885-3780 3600-3500	**3800±25** **3545±30**	3825-3780 3585-3530	3840-xxxx xxxx-3495	IV	
TCW SW Finland all (n=34)	3900±50 3530±60	3950-3845 3605-3500	3990-3810 3620-3420	3900±60 3445±85	3970-3840 3535-3375	4005-3780 3600-3285	IV	
TCW SW Finland crust and bbt (n=10)	3920±75 3560±65	3970-3830 3635-3530	4075-3800 3655-3420	**3840±90** **3440±105**	3890-3730 3565-3365	4000-xxxx xxxx-3260	IV	
Late CW all (n=23)	3735±70 2905±115	3785-3660 3065-2780	3890-3595 3250-2675	3660±75 2940±125	3720-3580 3080-2805	3825-xxxx 3235-2730	IV	
Late CW crust and bbt (n=12)	3710±85 3140±100	3795-3640 3275-3060	3875-3540 3325-2950	**3540±95** **3195±100**	3630-3395 3325-3140	3715-3380 3340-3000	IV	
Corded Ware all (n= 17)				2990±100 2210±100	3040-2880 2290-2110	3200-2970 2430-2030	V	
Corded Ware crust and burnt bone (n= 13)				**2910±70** **2210±90**	2960-2800 2280-2110	3050-2780 2400-2000	V	in the original paper, the 68,2% and 95,4% columns have changed place

6 DISCUSSION

6.1 ON THE RADIOCARBON DATING OF THE NEOLITHIC POTTERY FROM EASTERN FENNOSCANDIA

6.1.1 TEMPORAL DISTRIBUTIONS OF THE CERAMIC PHASES

In Paper I, the validity of the Finnish archaeological radiocarbon database was tested, and its use in summed probability distributions (SPD) as a population proxy was considered. This was also put into use in a subsequent paper (Tallavaara et al. 2010), and in the dissertation project of Miikka Tallavaara (2015), and later in several other papers (e.g. Tallavaara & Pesonen 2020). In this dissertation, actual SPDs were used only in Paper V, but this approach is discussed again in this section. In the following, the summed probability distribution of the radiocarbon context dates connected with each of the ceramic types discussed here (Säräisniemi 1 Ware, Sperrings 1 Ware, Sperrings 2 Ware, Jäkärlä Ware, Early Asbestos Ware, Typical Comb Ware, Late Comb Ware, and Corded Ware) are compared with direct charred crust and birch bark tar radiocarbon dates. It should be noted that here MRE corrected charred crust dates are used according to the values calculated in Paper IV. Since the applied methodology enables the upgrading of analyses by adding new data, new dates published after Papers II-IV are also used (Nordqvist 2018; Nordqvist & Mökkönen 2016 a; 2018; Pääkkönen et al. 2016; Mökkönen & Nordqvist 2018), and MRE correction is applied in cases when isotopic values rise above -26‰ (coastal samples). However, only three such samples come from the coastal Oulu region in northern Ostrobothnia; the others are either from inland contexts or have a terrestrial/freshwater isotope signal.

For comparison, the distributions of other Neolithic ceramic types (Pit-Comb Ware, Rhomb-Pit Ware, Kierikki Ware, Pöljä Ware, Orovnavolok Ware, Zalavruga Ware, Voynavolok Ware, Kiukainen Ware, and Palayguba Ware) are also presented here. The data was collected from publications (Nordqvist & Mökkönen 2018; Pesonen 2004; 2006; Lesell 2005; Karjalainen 2002; Tarasov et al. 2017; Nordqvist 2018; Hallgren 2008), with the addition of some unpublished information. It should be noted that these dates are not MRE corrected, and the summed probability distributions should only be regarded as tentative. The reservoir effect problem has the most potential effect in the case of Kiukainen Ware, which is highly coastal in nature; some stable carbon isotope values do indeed indicate marine components in the charred crust (see Appendix 2).

The summed probability distributions from all the radiocarbon dates, as compared to those using direct dating materials only (charred crust and birch bark tar), differ remarkably, as shown in the example of Jäkärlä Ware (Fig. 6.1). Such comparisons illustrate the real effects of the use of different sample materials and call for acknowledging the disparate factors that affect radiocarbon dates (see further discussion in Chapter 6.1.2).

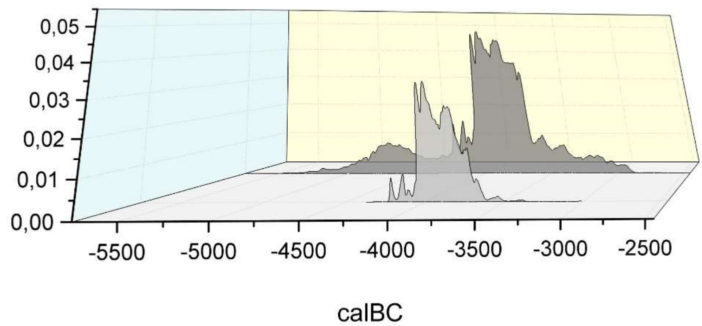

Figure 6.1. A comparison between the use of different radiocarbon dated materials. Summed probability distributions of radiocarbon dates associated with Jäkärlä Ware. In light grey, radiocarbon dates derived only from charred crust and birch bark tar (n=8), and in dark grey all radiocarbon dates connected with Jäkärlä Ware (n= 28). Original dates in Paper IV and Appendix I (Hela-3075 left out).

Although they are a powerful tool for the estimation of population dynamics, at least on the qualitative level, the SPDs for eastern Fennoscandian Neolithic pottery also reveal some other interesting features. The most remarkable minimums are found in the period before the arrival of Typical Comb Ware, between ca. 4250–4000 calBC, after which the dramatic rise in the curve begins (Fig. 6.2). The same characteristic is also visible in the kernel density estimate (KDE) plot of the same dates (Fig. 6.2). The 4250–4000 calBC drop in the curve happens during the period when Sperrings 2 Ware, Jäkärlä Ware, Pit-Comb Ware, and Early Asbestos Ware were all being used in eastern Fennoscandia. This drop is also visible in the SPDs compiled from all radiocarbon materials in Finland, especially in northern Finland (Tallavaara et al. 2010: Fig. 5), and to some degree also in the site frequency curve for northern Ostrobothnia (Tallavaara & Pesonen 2020; Jörgensen et al. 2020). This suggests that the drop in the SPD of the northern Finland radiocarbon dates is not an artefact caused only by the end of ceramic production but may also be due to other reasons which will require further study.

The maximum period in the curve lasts until ca. 3400 calBC, which leads to a plateau until a dramatic peak and drop ca. 2850–2800 calBC. This peak, which repeats itself in several separate curves (Pöljä Ware, Corded Ware, Zalavruga Ware, and Orovnavolok Ware), is a peculiar one, and may well be connected to oscillations in the radiocarbon calibration curve occurring only at this time, thus blurring for example the beginning of the Corded Ware phase (see also Fig 6.12; Piličiauskas 2018: 227; Paper V). In the KDE plot the peak and drop are smoothed out, which provides another reason to view this as an artefact of the calibration curve. Also, there is no peak at 2850–2800 calBC in the national Finnish curve (see Tallavaara et al. 2010: Fig. 5). After this the curve is steady, without major breaks. The diminishing of the curve to the end of the Final Neolithic results from the choice of the study material – Bronze Age ceramic styles have not been evaluated in this study.

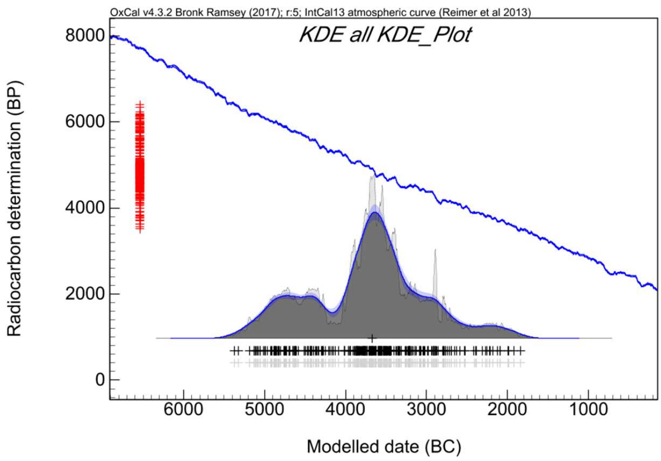

Figure 6.2. Summed probability distribution (light grey) and Kernel density estimate plot (dark grey) of the summed probability distribution of all charred crust and birch bark tar dates for the Neolithic pottery of eastern Fennoscandia (n= 330, Hela-3075, GrA-63515 and GrA-63539 excluded).

6.1.2 BAYESIAN INFERENCE AND SOME DISCUSSION ON BOUNDARIES

The Bayesian modelling of the radiocarbon dates in Papers II-V has been done with a boundary option, where the assumption is that the beginning and the end of the phase took place over a relatively short period of time. This may not seem intuitively justified in every instance, as the processes involved in the introduction and abandonment of certain pottery types (or whatever archaeological phenomena) may have been disparate. In addition to these regular boundaries, the use of so-called sigma boundaries (Fig. 6.3; Bronk Ramsey 2019) seems to be a practice worth considering, as it takes account of the possibly slow beginning and end for the phase. In the following, these boundary types are experimented with using a data set of Jäkärlä Ware radiocarbon dates. The results are statistically overlapping. Even if the mean values of the boundaries differ a little, there is no statistical difference between the two types of boundaries (Fig. 6.4).

Figure 6.3. Regular boundary function (upper), and sigma boundary function (lower) in Oxcal. Reproduced with permission from Oxcal manual: *https://c14.arch.ox.ac.uk/oxcalhelp/hlp_analysis_oper.html* (Bronk Ramsey 2019; cf. also Bronk Ramsey 2009).

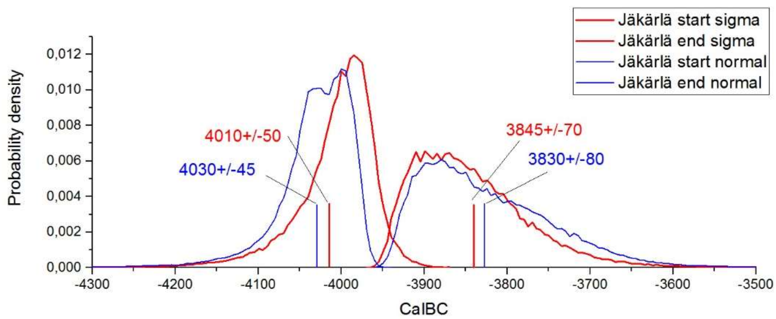

Figure 6.4. A comparison between model runs made with a regular boundary function (blue lines) and a sigma boundary function (red lines). The starting date for the Jäkärlä phase is little later with the sigma boundaries (20 years difference), and the end of the phase a little earlier (15 years difference). The values are statistically overlapping. The numbers shown are mean values for the boundary starting and ending points. The data set was Jäkärlä Ware charred crust dates (n= 8) (see Appendix 1).

Paper III uses Bayesian modelling to estimate the timing of an event by using phase boundary analysis. A boundary is then defined between those dates predating the event and those postdating the event. This approach is naturally dependent on the selection of the dates (see Mökkönen & Nordqvist 2014). However, when the number of dates is large, the role of individual dates is small. Highlighting single differing dates does not justify the abandonment of the whole model, and any scrutiny of single dates should be done within the Bayesian framework, not outside it.[9]

[9] In their critique of the paper, Mökkönen & Nordqvist (2014: 48) highlight two radiocarbon dates from the Kitee Sarvisuo site (Hela-152, 5005±70 BP) and Savonlinna Pääskylahti (Hela-112, 4875±70 BP) as being sub-optimally referenced. According to them, the dates should be regarded as predating the breakthrough of the River Vuoksi. In Paper III, we chose not to use these dates for dating the event itself, as the topography of the sites allows for both pre- and post-dating (the shore below the site has also

The application of Bayesian models provides a consistent way to handle radiocarbon date information in a statistically coherent manner. The method could also be expanded to study different kinds of prehistoric phenomena that have beginning and end points in time. It does not have to be limited to the simple phasing of a basic chronology, but could, for example, also be used to study the advent of agriculture, the use of certain tool types, or the lifecycle of pit houses - indeed, for any phenomenon that has a position in time and has been radiocarbon dated. The use of Bayesian modelling on a smaller scale in archaeology, for example on the stratigraphies of sites, has so far been quite restricted in eastern Fennoscandia (see however Oinonen et al. 2013 b), but it could be utilised more often in order to improve knowledge of site formation processes. In contrast, ca. 73% of radiocarbon dates from Britain provided by English Heritage had already been modelled with Bayesian statistics by the end of the 2000's (Bayliss 2009: 134).

6.1.3 DIFFERENT RADIOCARBON DATING MATERIALS - WHAT IS THE FUTURE?

Obviously, using charcoal samples from the cultural layers of settlement sites or other ancient sites is not an optimal way to obtain chronological information. These kinds of samples do not always have contextual information, and sometimes are prone to date natural events instead of archaeological events (e.g. Surovell & Brantingham 2007; Mökkönen 2014). When used within large sets of dates these disadvantages probably have less of an effect, as discussed in various SPD-studies (e.g. Tallavaara et al. 2010; Tallavaara 2015), but in smaller numbers their use cannot be recommended. Of course, this does not concern charcoal samples with solid contextual information, e.g. from hearths, graves, and house structures. The evaluation and ranking of radiocarbon dates as done by Seitsonen et al. (2012) in Karelia is one way to manage the dates systematically.

Wood and bone have poor rates of preservation in the acidic soils of eastern Fennoscandia, but in waterlogged conditions organic materials may survive remarkably well. The use of these materials for dating is obviously preferred when possible, as long as one remembers the potential risk of reservoir effect in bone datings, especially when it comes to dating bones of fish and marine mammal consumers. Several kinds of organic materials, such as grains, seeds, and nuts, also occasionally hair and fur, can be dated, and with the AMS-technique the future of radiocarbon dating these types of small fragments is bright. Furthermore, these organic materials rarely involve any error sources other than the potential contextual problem of small particles that may intrude

remained more-or-less in the vicinity of the site after the breakthrough). However, the dates are used in the phase model for Typical Comb Ware.

into older layers and thus date unwanted events and phases (e.g. Minami et al. 2017). Terrestrial plants in particular are favourable since they have a direct link to atmospheric radiocarbon through photosynthesis and thus record an annual signal.

Since its invention, the new method for dating burnt bone has brought new certainty to chronological studies, especially for the Mesolithic chronology of eastern Fennoscandia. While there seems to be no reservoir effect problems involved in burnt bone, one must remember that the radiocarbon signal might actually come from the firewood that caused the burning, and thus the potential for the "old wood effect" remains. Still, the context of burnt bone materials is usually solidly linked to a specific period, and so far it seems that most of the burnt bone dates are reliable. However, there may be problems in combining several small burnt bone pieces to create one sample, as is shown in some examples (e.g. Pesonen et al. 2020). At the moment, burnt bone dating is the primary option for dating many of the periods in the prehistory of eastern Fennoscandia, and it should especially be utilised, for example, for the dating of periods where charred crust or birch bark tar do not exist.

The strength of dating charred crust and birch bark tar lies in their intrinsically secure context as directly associated with a ceramic period or – in the case of birch bark tar haftings – with an artefact type. Birch bark tar is one of the most reliable dating materials, whether it is attached to a pot, found as a lump, or recovered as remains of an artefact hafting. The earliest postglacial radiocarbon date from eastern Fennoscandia is from a piece of birch bark tar hafting.[10] Birch bark tar has also other qualities relevant in modern archaeology; it is possible to recover ancient DNA from inside birch bark tar (Kashuba et al. 2019). This is because the process of preparing birch bark tar involves chewing it at some stage (e.g. Pesonen 1994; 1999 a), and in this way human saliva becomes encapsulated inside the tar.

Charred crust dates will also probably be used in the future for the dating of pots, as the materials re widely available (although not for all periods of eastern Fennoscandian prehistory) and easily sampled. Furthermore, the isotope measurements from the crust provide added information on the possible use of the vessels (e.g. Mökkönen & Nordqvist 2019). The constant problem with charred crust dates is their vulnerability to the reservoir effect, as the crust derives from the ingredients cooked in the pots. So far, only the marine reservoir effect has been considered truly impactful in the eastern Fennoscandian context (Paper II), but in the future the potential influence of freshwater reservoir effect should be investigated. Some preliminary estimates of the freshwater reservoir effect have already been made in northwestern Russia (Zhulnikov et al. 2012), in northwestern Finland (Oinonen et al. 2020),

[10] Jokivarsi 1 site in Joensuu, 9560±60 BP; Tallavaara et al. 2014a.

and in the Karelian Isthmus (Seitsonen et al. 2016), but more research is needed.

The future of radiocarbon dating probably lies in utilising smaller components derived from dated materials. For example, dating programmes have been reported where parts of lipid chains inside the ceramics were dated, thus aiming at direct dating of the particular resource/ food ingredient prepared or stored in the pot (Stott et al. 2001; 2003; Berstan et al. 2008; Casanova et al. 2020). In this light, compound-specific radiocarbon analyses are probably the next major development in the field, particularly as the AMS methodology gradually develops towards incorporating smaller sample sizes.

6.2 CONTINUITY AND DISCONTINUITY IN THE EARLY, MIDDLE, AND LATE NEOLITHIC OF EASTERN FENNOSCANDIA: REFLECTIONS FROM BAYESIAN CHRONOLOGIES

In my dissertation papers – and in the light of Bayesian models – one outcome was repeatedly revealed: problems regarding the continuity and discontinuity of the population dynamics and settlement history of eastern Fennoscandia. Obviously, the ceramic typology alone is not enough to solve these problems: other artefact categories, our perception of the world and the meaning of neolithisation (Herva et al. 2014), the role of systematics in settlement structures (e.g. Tallavaara & Pesonen 2020) and in ritual behaviour (Ahola 2019) should also be explored in order to understand the continuity and/or discontinuity of the actual populations. Ancient DNA-studies could be another future tool, but in the case of eastern Fennoscandia we are currently very far from discovering any facts about the actual genetic lineages of the Neolithic potters. However, some promising projects and results also show future promise in this respect (e.g. Kashuba et al. 2019; Översti et al. 2019).

From the historical point of view, I feel that the ultimate continuity theory cannot be the sole model for human prehistory, especially given the small and vulnerable habitations that populated the large areas of eastern Fennoscandia. There are of course no precisely accurate estimates of the numbers for these local populations, but the relative level of the population in Finland has been estimated on the basis of summed probability distributions (Tallavaara et al. 2010; Tallavaara 2015) following examples from Central Europe (e.g. Gamble et al. 2005; Shennan & Edinborough 2007) and elsewhere (e.g. Fidel & Kuzmin 2007). Population size reflects the so-called life history theory, where the available resources dictate many cultural characteristics, for example individuals' ability to produce offspring and successfully raise new generations (Binford 2002; Hill & Hurtado 1996; Shennan 2009). Climatic characteristics and environmental productivity have also played decisive roles in the population size of societies relying on hunting, fishing, and gathering in eastern Fennoscandia (Tallavaara & Seppä 2012; Tallavaara 2015), although the role of human agency in the form of cooperation, migration, violence, and epidemics should not be forgotten.

Human mobility is obviously associated with the genetic composition of populations. Eastern Fennoscandia is largely devoid of proper material for the sequencing of ancient DNA for humans, and as a result the references made are usually to the rest of Europe (e.g. Bramanti et al. 2009; Haak et al. 2010; 2015; Lazaridis et al. 2014; Malmström et al. 2015; Allentoft et al. 2015; Jones et al. 2017; Mittnik et al. 2018; Saag et al. 2017; Olalde et al. 2018). The major events in the genetic prehistory of the wider European continent include: some genetic continuity from the Mesolithic to the Neolithic (western hunter-gatherers, WHG), Anatolian farmer-related genetic flow into Central and Southern Europe during the Early Neolithic, and the introduction of Steppe-related ancestry in the Middle and Late Neolithic, along with the Yamnaya-phenomenon and Corded Ware culture. Focusing on eastern Fennoscandia (and Baltic States area), the results show that an eastern hunter-gatherer (EHG) genetic component was present in the area of the Mesolithic site of Yuzhniy Olennij Ostrov (Der Sarkissian et al. 2013; Mittnik et al. 2018). EHG was also present in the Baltic Narva culture stage, which shows both EHG and WHG components (as do Mesolithic samples from the Baltic States), but the latter diminished during the Middle Neolithic Typical Comb Ware stage, which again featured more of an EHG component (Jones et al. 2017; Saag et al. 2017; Mittnik et al. 2018). Steppe-ancestry characteristics arrived in the area along with the Corded Ware culture (Jones et al. 2017; Saag et al. 2017; Mittnik et al. 2018). The Bronze Age Bolshoy Olennij Ostrov cemetery in the Kola Peninsula suggests a Central/East Siberian origin for the population (Der Sarkissian et al. 2013; Lamnidis et al. 2018). Iron Age DNA from Finland also displays strong mitochondrial variation between the sampled sites, which furthermore contradicts the present distribution of mtDNA in Finland (Översti et al. 2019).

So far, genetic studies do not offer much to our understanding of Neolithic mobility and cultural formation in the area of eastern Fennoscandia. However, there are three points in time and associated genetic interpretations that deserve attention within this theme: 1) according to the current information, there was no change in genetics between the Mesolithic and the Early Neolithic in the area; 2) Typical Comb Ware introduced a new wave of EHG components into eastern Fennoscandia; and 3) Steppe ancestry characteristics – along with pastoralism (and possibly farming) – were introduced via the Corded Ware culture (e.g. Cramp et al. 2014). Within these broad lines of genetic shifts, we may be able to better understand the relatively sweeping change in material culture during the Typical Comb Ware and Corded Ware periods in eastern Fennoscandia: these radical changes were brought about by the migration of people. The other periods of the Neolithic are still obscured, as no ancient human DNA is available for these periods.

From the archaeological perspective, the discontinuities seen as interruptions in ceramic traditions, and in taking up new way to produce pots (and assimilating all the other cultural attributes that were adopted along with the new ceramic types), do not necessarily imply the annihilation and replacement of entire populations. As pot making was both a skill and a tradition that was probably inherited within families and/or households (e.g. Arnold 1999; Varonen 2007: 171–173), discontinuities in ceramic traditions may in milder cases simply denote a disconnection in the inheritance, learning, and teaching of a style as a result of stress within the society that may have arose for any number of reasons. On the other end of the spectrum, the discontinuity revealed by a more-or-less total change in the archaeological record may well indicate the replacement of a population. However, even this complete replacement of material culture does not have to imply a total annihilation of the previous population, but rather the introduction of a powerful and superior cultural pulse overriding the old ways.[11]

6.2.1 EARLY NEOLITHIC POTTERY IN THE NORTHERN PARTS OF EASTERN FENNOSCANDIA

The results of the modelling indicate that Säräisniemi 1 Ware was the first pottery ever produced in eastern Fennoscandia, and that Sperrings 1 Ware came into use only some centuries later. This fits well with the idea of common roots but separate formation areas and dispersion routes for these pottery styles or innovations (Piezonka 2015; also Nordqvist 2018: 92). Säräisniemi 1 Ware has been found both on the shores of the Arctic Ocean and in the inland regions of northwestern Russia and northern Finland, as well as in some sites on the former coast of the Baltic Sea in northern Ostrobothnia. In the light of current Säräisniemi 1 datings, the pottery was likely introduced as early in northwest Russia as on the shores of the Arctic Ocean (by 5190 calBC) and spread only ca. 100 years later into northern Ostrobothnia. The earliest Sperrings 1 dates in northern Ostrobothnia are ca. 200 years younger than the earliest Säräisniemi 1 dates from the same region, perhaps indicating a delayed introduction of the Sperrings-idea into the north. In northwestern Russia, Sperrings 1 has some context dates as far back as ca. 5500 calBC. The reliability of these contexts is, however, not so well attested (see Piezonka 2008; Nordqvist 2018: 90), and the actual beginning of Sperrings 1 according to Oxcal models in 5155 calBC may well be taken as a beginning date for this pottery in eastern Fennoscandia, even though single dates point to an earlier

[11] For a discussion of the boundary between Late Neolithic and Bronze Age in Finland, which may have included a population bottleneck and the arrival of new populations, see (Lavento 2001; 2012; Sundell et al. 2010; 2014; Tallavaara et al. 2010).

starting point (Nordqvist 2018: 90).[12] This is a property of Bayesian modelling: within a large number of dates, the relative weight of a single date is fairly small.

According to the Oxcal model, the end boundary of Säräisniemi 1 Ware is ca. 4455 calBC (Paper II). One of the original samples in Paper II from the Ylitalo site in Rovaniemi (Hela-40, MRE corrected in Paper II as 5283±212 BP) is surprisingly young, with a calibrated mean of 4110±230 calBC. There is also another date that was omitted as an outlier in Paper II, from the Jokkavaara site in Rovaniemi, of 5070±80 BP (Hela-57) with a calibrated mean of 3860±90 calBC. During the writing of Paper II, these values seemed far too young, considering the length of Säräisniemi 1 pottery production. However, in the light of a new charred crust date from Oulu Latokangas, 5025±35 BP (GrA-63486) with a calibrated mean of 3840±70 calBC (Nordqvist & Mökkönen 2016 a),[13] these dates may no longer need to be considered outliers. The Säräisniemi 1 tradition may actually have continued until the beginning of the 4th Millennium calBC, at least in northern Ostrobothnia and southern Lapland. In the figure below, new phase boundaries were estimated taking into account all three of these younger charred crust dates, with the result that the end boundary in particular shifts radically younger, to 3815±80 calBC (Fig. 6.5; also Fig. 6.8). Obviously, more datings are needed in order to fill the gap between these younger dates and the larger mass of dates in the older end of the phase.

Some of the youngest dates connected with Sperrings 1 pottery come from southern Lapland and northern Ostrobothnia. The single calibrations of the young Sperrings 1 dates are: 4250±135 calBC (Hel-2979, 5430±120 BP, Simo Tainiaro, charcoal); 4230±135 calBC (Hel-2977, 5410±120 BP, Simo Tainiaro, charcoal); 4230±125 calBC (Hel-3059, 5410±110 BP, Oulu Latokangas, charcoal).[14] Whatever the events behind these fairly young Sperrings 1 context dates are, the production of this type of pottery ceased north of Arctic Circle, with rare exceptions extending into the Early Metal Period. Regarding these late Sperrings 1 and Säräisniemi 1 radiocarbon dates, questions regarding the identification of the pottery styles and the contexts of the radiocarbon dates need to be highlighted in future studies.

[12] There is a number of context dates for both Sperrings 1 and Säräisniemi 1 ceramics from the Kola Peninsula, Leningrad Oblast, and the Karelian Republic, but the sites are usually multiperiod, and the association between the ceramic types and the dates is not well attested. These dates are reviewed by German (2009).

[13] However, the material that this radiocarbon date is based on is described as charred crust or paint, which leaves some doubt about the reliability of the result (cf. Nordqvist 2018: Table 2).

[14] All dates are from sites that also have Säräisniemi 1 pottery. Thus, the affiliation of the dates with Sperrings 1 is not certain.

The interruption of pottery production in the northern parts of eastern Fennoscandia by the end of 5th Millennium calBC (north of Arctic Circle) seems to be quite dramatic. Neither the pattern of radiocarbon dates (cf. Tallavaara et al. 2010: Fig. 5) nor the distribution of other archaeological features point to a population break, but the first prominent ceramic production after Säräisniemi 1 Ware apparently takes place only in the beginning of the Early Metal Period, with the arrival of the rather visible cultural "package" of Lovozero Ware (e.g. Carpelan 1979; 2004 b) and Imitated Textile Ware (or Vardöy Ware; Arponen 1992; 1994; Carpelan 1970; 1979; 2004 b; Jörgensen & Olsen 1987), almost two thousand years later. A rare exception in Lapland is the Vuopaja site in Inari, which has produced Middle Neolithic Voynavolok Ware (see Carpelan 2004 b; Nordqvist 2018). However, Middle and Late Neolithic asbestos and organic tempered wares are present in the Kola Peninsula and adjacent regions (see Nordqvist 2018: 106), illustrating the insufficient research situation on the Finnish side. Three relatively late Säräisniemi 1 radiocarbon dates from the Rovaniemi and Oulu regions discussed above also point to the continuation of pottery production in the Middle Neolithic north of Arctic Circle.

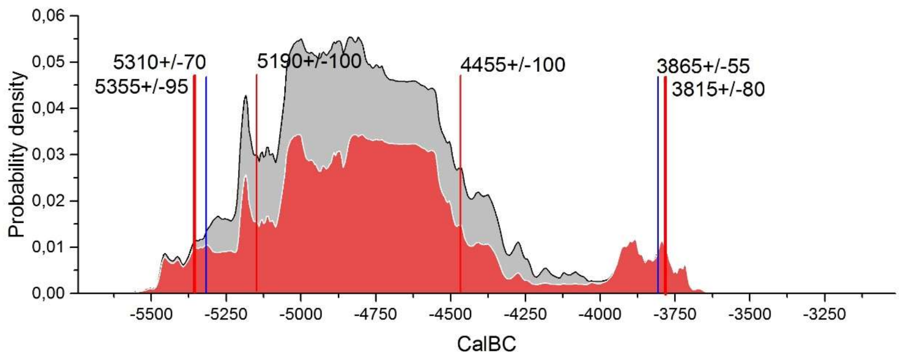

Figure 6.5. Summed probability distributions of all the dates connected with Säräisniemi 1 Ware (grey area, n= 43), compared to only charred crust dates (red area, n= 27), with modelled starting and ending boundaries for all context dates (blue vertical lines = mean dates for boundaries), and modelled starting and ending boundaries from Paper II: Table 2, where only charred crust dates without the two outliers (as seen at the time) Hela-40 and Hela-57 were used (red vertical lines = mean dates for boundaries), and revised boundaries for all charred crust dates (including Hela-40, Hela-57, and GrA-63486; thick vertical lines = mean dates for boundaries). The data can be found in Appendix 3.

The reason for the termination of pottery production north of Rovaniemi has not been studied in detail. Markku Torvinen has speculated that pottery may never have been accepted by the mobile hunter-fisher-gatherer societies of the north because it was so heavy and fragile, and so they may have turned to other types of containers, perhaps of wood or leather (Torvinen 2000: 24). A few samples of lipid composition in the pottery vessel walls have been analysed for Säräisniemi 1 Ware. They contain remains of both terrestrial and aquatic components (Papakosta & Pesonen 2019) but give no hint about a possible variation or change in the use of resources which could further explain why pottery making ceased in the northern parts of eastern Fennoscandia at the end of Early Neolithic.

6.2.2 EARLY NEOLITHIC POTTERY IN THE SOUTHERN PARTS OF EASTERN FENNOSCANDIA

South of Rovaniemi, the ceramic succession differed from that north of the Arctic Circle. According to current models, Sperrings 1 Ware started its spread ca. 5155 calBC, although some (suspicious) earlier dates are available from northwestern Russia (e.g. Nordqvist 2018: 90; German 2009). Similar to Säräisniemi 1 Ware, Sperrings 1 Ware also quickly spread to all kinds of environments, even to the far-away archipelago of the Åland Islands (Stenbäck 2003; Hallgren 2004; 2009). This early habitation of the islands was, however, fairly short-lived, as the modelling of Åland Sperrings 1 dates suggests only ca. 250 years of early occupation (ca 5100–4855 calBC), although the small number of samples allows wider margins for the beginning and end of the phase. Furthermore, there are also Sperrings 2 sites in the Åland Islands, but these have not yet been radiocarbon dated. The same applies to Jäkärlä Ware and Typical Comb Ware sites, which are rather few in number in the islands (e.g. Dreijer 1941; 1983; Stenbäck 2003; Nuñez 1986). There probably was no actual gap in the ceramic production, other than the same gap observed in the mainland between Sperrings 2 and Jäkärlä Wares, but the settlement pattern may have been less intense after Sperrings 1 Ware.

According to the Oxcal models, Sperrings 1 pottery ends at 4335 calBC and Sperrings 2 pottery begins at 4510 calBC, indicating almost 150 years of overlapping use. The youngest charred crust date of Sperrings 1 Ware is from the Raasepori Timmerkärr site (Hela-3175; 5451±44 BP), with a calibrated mean of 4300±45 calBC. The oldest charred crust date from Sperrings 2 Ware is from the Pielavesi Kivimäki site (GrA-62077; 5680±40 calBC), with a calibrated mean of 4515±50 calBC. Both the single dates and the Oxcal models thus indicate an overlap between these two styles.

Sperrings pottery production came to an end with Sperrings 2 Ware, though one may see a continuation of this tradition in eastern Finland, where the use of asbestos as a temper as invented for Sperrings 2 pottery and was still used in Kaunissaari Ware until ca. 3845±60 calBC. However, the traditional Sperrings 2 pottery with its mineral or organic temper quite neatly stops already around 4225±50 calBC. In southwestern Finland, a new type, Jäkärlä Ware, emerges only ca. 4030±50 calBC, indicating a ca. 200 year gap between the Sperrings 2 and Jäkärlä ceramic traditions. When looking at the posterior probability distributions for the end of Sperrings 2 Ware and the beginning of Jäkärlä Ware (based on charred crust and birch bark tar dates), it seems statistically impossible that these two groups could have had any chronological contact (Paper IV: Fig. 3). This situation in southwestern Finland thus must – according to available dates – be interpreted as a case of discontinuity. In the summed probability distribution curve, no such gap is present in the southern parts of Finland (Tallavaara et al. 2010: Fig. 3), thus potentially indicating only a discontinuity in the ceramic production rather than in the settlement pattern as well.

In Paper IV, the relationship of Sperrings 1-2 Wares with southwestern Finnish Jäkärlä Ware was studied. Earlier views of the long history of Jäkärlä Ware production can now be abandoned in the light of new evidence, as the charred crust dates for Jäkärlä Ware are very consistent and the whole sequence can be modelled to 5030–4830 calBC according to these. The new dates also provoke an interesting question about the possible contemporaneity of Jäkärlä Ware and Typical Comb Ware (cf. Edgren 1966; Asplund 1995), which now seems possible in light of the modelled dates for southwestern Finnish Typical Comb Ware. In southwestern Finland, the beginning of Typical Comb Ware is modelled to ca. 3840 calBC. Within the larger data set, however, the Oxcal model reduces the start of Typical Comb Ware to 3800 calBC. The comparison of Jäkärlä Ware and Typical Comb Ware single radiocarbon dates from the Nousiainen Kukonharja 2 and Mynämäki Aisti sites show statistical contemporaneity in the Mynämäki Aisti site, but not in the Nousiainen Kukonharja 2 site. In the end, to solve this question thoroughly more dates are needed for both styles in this region.

As noted earlier, Early Asbestos Ware remains a somewhat enigmatic group of ceramics, as it potentially includes two separate typological groups (Pesonen 1996 a; 1996 b; Nordqvist 2018: 63). With this in mind, the model dating presented in Paper III can be revisited. Indeed, the sequence for Early Asbestos Ware is quite long, 4670–3845 calBC. However, there are two groups of dates, as visualized in Fig. 6.6, where the younger group starts with a date from the Kitee Sarvisuo site (Su-2478, 5440±40 BP) that is calibrated to 4295±40 calBC, which could mark the beginning of the Kaunissaari phase. However, there are only four charred crust and birch bark tar dates from Early Asbestos Ware altogether, the oldest one being from the Lappeenranta Saksanniemi site (Hela-2871, 5421±38 BP), calibrated 4280±45 calBC, and the youngest one from the Outokumpu Sätös site (GrA-62218, 5150±35 BP; Nordqvist & Mökkönen 2016 a), calibrated 3945±60 calBC. The three dated sherds from Lappeenranta Saksanniemi (KM 12169:75, Hela-2871), Liperi Kyläsärkkä (KM 23111:69, Hela-2872), and Rääkkylä Lappalaissuo (KM 27572:1, Hela-2875) all represent Kaunissaari Ware and are dated to this younger portion of the Early Asbestos Ware sequence. The situation is still not clear, as several of the earlier context dates are from sites that also have obvious Kaunissaari Ware. Furthermore, the youngest charred crust dating from the Outokumpu Sätös site has been classified as asbestos tempered Sperrings 2 Ware (Mökkönen & Nordqvist 2019: Table 1). More research is needed in order to establish a firm radiocarbon date basis for both of these styles, along with a new and a more thorough stylistic analysis on the pottery itself.

The beginning of the production of Jäkärlä Ware is an interesting question in itself. While Jäkärlä Ware is clearly separate and "different" from any other pottery style in its use of temper and decoration, it still has some occasional features in common with Sperrings 2 Ware. So far, there does not seem to be any inspirations for Jäkärlä Ware other than Sperrings 2 Ware. The suggested role of Pit-Comb Ware seems too far-fetched, as the pottery in itself is different in its character and decoration, and there is practically no geographical contact between these two pottery types (Paper IV; Nordqvist & German 2018). Furthermore, Jäkärlä Ware sites also seem to reveal an isolated nature in their use of raw materials, which is strongly based on local materials such as porphyrous stones, for both polished and knapped tools (e.g. Edgren 1966; also Asplund 1998).

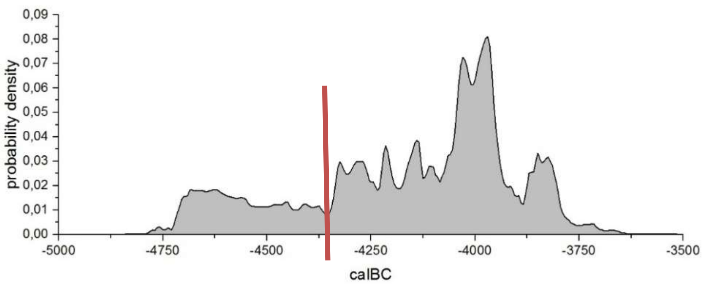

Figure 6.6. SPD of Early Asbestos Ware radiocarbon dates (n= 24, direct and context dates, including the new date from the Sätös site in Outokumpu (GrA-62218, 5150±35 BP; Nordqvist & Mökkönen 2016). The vertical line marks the possible division point between asbestos tempered Sperrings 2 Ware and Kaunissaari Ware.

The role of Early Asbestos Ware is problematic. While it could be seen as a transition point between Sperrings 2 and Jäkärlä Ware via the use of asbestos temper in eastern Finland, the typology and chronology between asbestos tempered Sperrings 2 Ware and Kaunissaari Ware is far from clear. The tentative chronological limit for these was placed at ca. 4300 calBC, i.e. a bit earlier than the end of Sperrings 2 Ware in general. With some reservations, this would perhaps suggest a developing situation for Kaunissaari Ware in eastern Finland. Jäkärlä Ware and Kaunissaari Ware have a visual resemblance: the pots are often decorated with broad, oval stamps and the decoration covers the whole surface of the pots. Indeed, the rest of the cultural "picture" of these two potteries also resemble each other, in their seemingly exclusive use of local materials and also in their apparently highly localized livelihood strategies (Paper III; Paper IV; Edgren 1966; Pesonen 1996 a; 1996 b; 2001). It is cautiously suggested, therefore, that Jäkärlä Ware and Kaunissaari Ware may be linked, and that these groups form a chronological horizon of their own as successor to Sperrings Ware, situated between the latter and Typical Comb Ware (Paper IV). Chronologically, Jäkärlä Ware would at this point seem to have a younger starting date than Kaunissaari Ware, but new radiocarbon dates for either of these types may change the situation, as both styles so far have only a few direct charred crust and birch bark tar dates.

The contemporaneity of Early Asbestos Ware and Typical Comb Ware is a situation parallel to the one in southwestern Finland between Jäkärlä Ware and Typical Comb Ware. However, in eastern Finland this situation is not probable, even though the posterior probability curves for the end of Early Asbestos Ware and for the start of Typical Comb Ware overlap somewhat (Paper III: Fig. 4a). Early Asbestos Ware ends by 3845±60 calBC, and Typical Comb Ware starts (according to Paper III) at 3820±25 calBC. Taking into account the dramatic lake-burst event and the ensuing environmental change, I would suggest that these changes were so radical, and the associated cultural impact so severe, that the production of Early Asbestos Ware ceased simultaneously with the arrival of Typical Comb Ware. Even though this dramatic event would have affected the whole Saimaa area, it is evident that the Typical Comb Ware advancement was more radical in southern Saimaa (involving population movement and replacement, as suggested in Paper III; also Mökkönen et al. 2017; Nordqvist 2018: 101), and the development was more traditional and indigenous in the northern parts of the lake system (Mökkönen et al. 2017; Nordqvist 2018). So far, there is no clear evidence on the continuation of Early Asbestos Ware production, either for the southern part of the Saimaa water system or for the northern shores of Lake Saimaa, after the appearance of Typical Comb Ware.

Charred crust radiocarbon dates for Pit-Comb Ware extend from ca. 4500 to 3000 calBC, which is a fairly long period for one pottery tradition, and there are some context dates suggesting an even earlier beginning (Lobanova 2004). It is suggested by Nordqvist and German (2018) that a particular dating series from the Vorob'I 4 site (SPb-1775, SPb-1777, SPb-1778, SPb-1779, SPb-1781, SPb-1782, SPb-1783, SPb-1785, SPb-1786 and SPb-1822) on Lake Onega probably has sample size-related issues and thus appears too young. Taking into account this aspect, Pit-Comb Ware is dated to ca. 4500–3500 calBC (Fig. 6.7).

Pit-Comb Ware is so abundant in the Karelian Republic that it has even been called the "Karelian culture" (cf. Nordqvist & German 2018). The role of Pit-Comb Ware in the disappearance of Sperrings 1-2 and Säräisniemi 1 Wares has not been discussed, but the production of these potteries do cease at approximately the same time as Pit-Comb Ware appears in the Karelian Republic and Leningrad Oblast. The origins of Pit-Comb Ware have been suggested to lie in central Russian Pit-Comb or Lyalovo Ware, or north of the actual Lyalovo area (e.g. Oshibkina 1978; Lobanova 1991; Nordqvist & German

2018). Pit-Comb Ware is also seen as a precursor for Typical Comb Ware and Rhomb-Pit Ware (e.g. Carpelan 1999: 258).

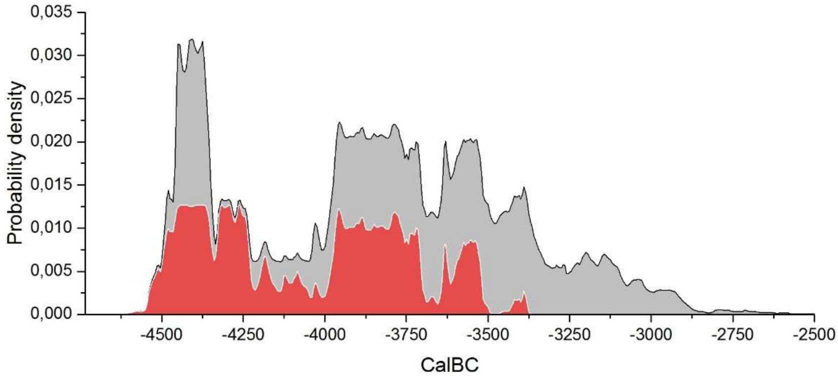

Figure 6.7. SPD of all Pit-Comb Ware -related charred crust radiocarbon dates (grey area, n= 18), compared with a SPD of the charred crust dates excluding the SPb-laboratory series from the Vorob'i 4 site (red area, n= 8). See the discussion on the validity of the radiocarbon dates in Nordqvist & German (2018).

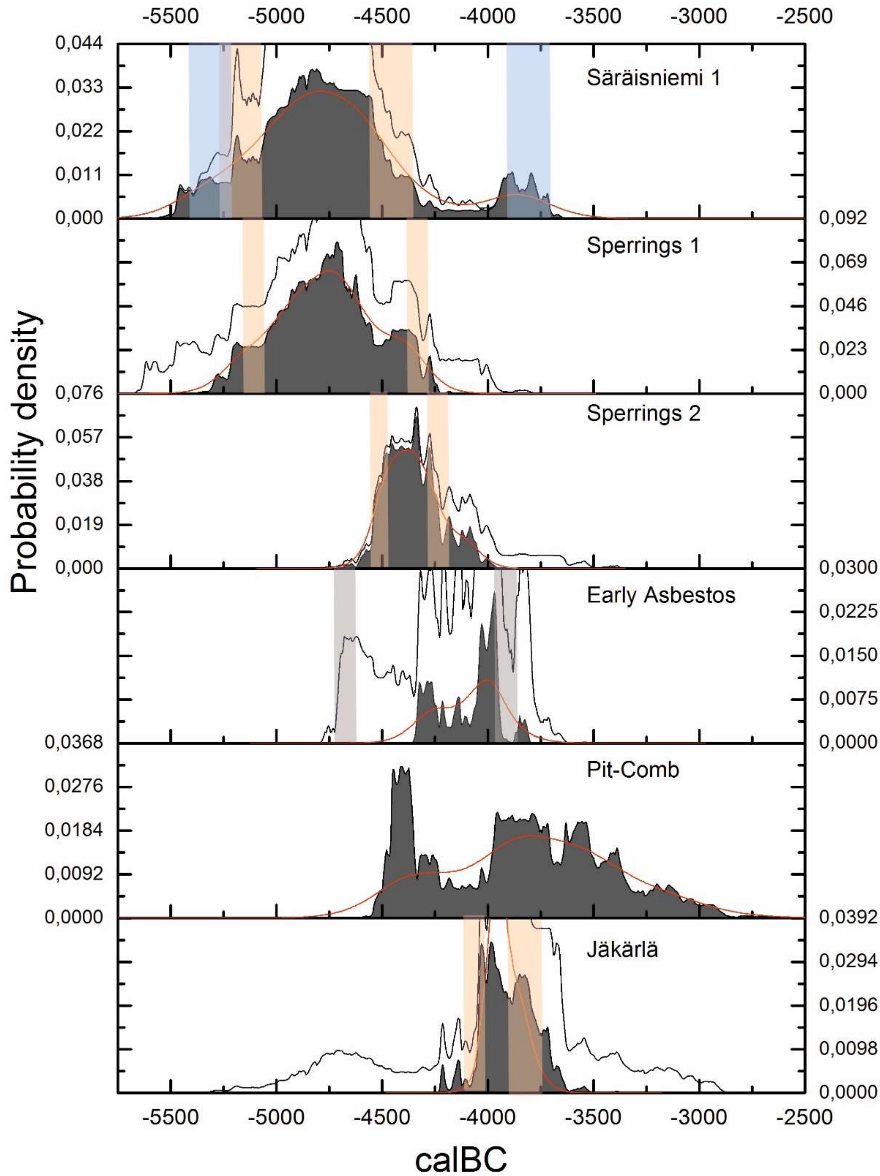

Figure 6.8. Summed probability distributions, kernel density estimates, and modelled boundaries of Early Neolithic ceramic styles in eastern Fennoscandia. The dark shading is the SPD of MRE-corrected charred crust and birch bark tar dates; the black lines indicate all the context dates of the specific ceramic style, and the red line the kernel density estimate of the crust and birch bark tar dates. The vertical bars indicate the mean values of the starting and ending boundaries for the styles; the red colour is for boundaries calculated on basis of charred crust and birch bark tar dates only, while the grey colour also includes context dates. In the case of Säräisniemi 1 Ware, the blue colour indicates the boundaries obtained with "young" charred crust dates (Hela-40, Hela-57, GrA-63486 included). The original boundaries for Säräisniemi 1 Ware are from Paper II, the boundaries for Early Asbestos Ware re from Paper III, and the boundaries for Sperrings 1 and 2 Wares are from Paper IV. Säräisniemi 1 Ware (n= 27), Sperrings 1 Ware (n= 40, GrA-63515 excluded), Sperrings 2 Ware (n= 18), Early Asbestos Ware (n= 4), Pit-Comb Ware (n= 18), and Jäkärlä Ware (n= 9, Hela-4075 excluded). Note: the probability densities are not in the same scale.

6.2.3 MIDDLE NEOLITHIC CERAMICS IN EASTERN FENNOSCANDIA

In Paper III, the Middle Neolithic Typical Comb Ware chronological position was modelled to 3815–3475 calBC in eastern Finland (for all radiocarbon dated materials). In Paper IV, Typical Comb Ware was modelled to 3840–3440 calBC (charred crust and birch bark tar dates) in southwestern Finland, and in the whole of Finland to 3800–3545 calBC (again, charred crust and birch bark tar dates). The last figure is a consensus date for this ceramic period and the values arrived at for southwestern and eastern Finland represent possible local variations in the material. Still, the beginning of the phase in the models match well enough. There is a stronger variation in the estimates of the ending boundaries. In the case of Typical Comb Ware, the SPDs visually show a longer duration for the phase, ca. 4000–3300 calBC (cf. Fig. 6.9). The phenomenon does not appear in the other models, which generally have a much lower number of dates than Typical Comb Ware does. This is a characteristic of Oxcal modelling and should be studied further in the future.

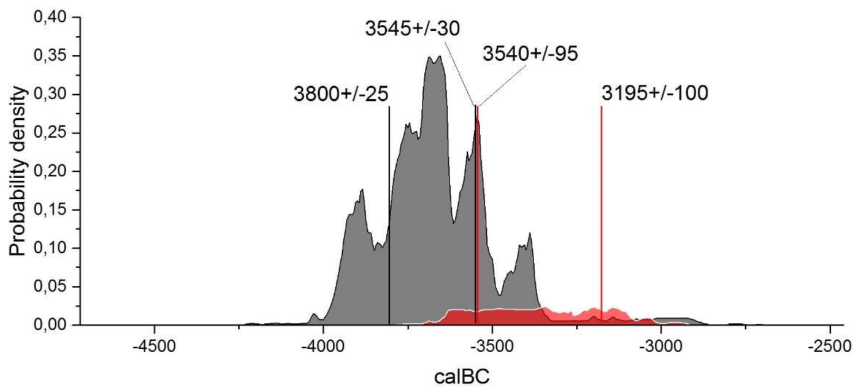

Figure 6.9. SPDs of Typical Comb Ware (grey area, n= 94, GrA-63539 excluded) and Late Comb Ware (red area, n=12) charred crust and birch bark tar dates, including posterior probability boundaries (mean values) for both phases.

The beginning of the 4th millennium calBC saw some dramatic changes in the material culture of the Neolithic societies in eastern Fennoscandia. Typical Comb Ware (or Comb-Pit Ware in Russian terminology) and Rhomb-Pit Ware (mainly in northwestern Russia) emerged and then spread into a large area in eastern Fennoscandia and the Baltic States. When compared to Jäkärlä and Kaunissaari Wares, these potteries are very different in their decoration, composition, technology, and variation. At this point in time, the basic characteristics of material culture also changed in many ways. At least within Typical Comb Ware, an eastern connection is clearly visible in the form of flint use (Vuorinen 1982; Manninen et al. 2003), the appearance of copper (Ikäheimo 2019; Nordqvist & Herva 2013), artefacts of sembra-pine, fishing gear (hook shafts, line sinkers; Minkkinen 2000) etc., not to mention the first true appearance of the pithouse tradition (Pesonen 2002; Mökkönen 2011a; Tallavaara & Pesonen 2020) and ritual behaviour in the recognisable form of red-ochre graves and potentially hierarchical use of adornments and weaponry in the graves (Ahola 2019; Ahola et al. 2016).

The appearance of Typical Comb Ware, at least in the area of Finland, was relatively quick and abrupt; one might even say overwhelming and opportunistic in terms of the resource use in various environments. The number of sites multiplied in comparison to Sperrings, Jäkärlä, and Kaunissaari sites (e.g. Tallavaara et al. 2010: Table 2). Sites appear in regions practically devoid of previous settlements, and pithouse villages also emerge for the first time in the prehistory of eastern Fennoscandia. For example, the enormous Rekikylä site with over 130 pithouses (some of them truly huge, even up to 150 m^2) was built on the (then) river mouth of the River Kiiminki in northern Ostrobothnia (Pesonen 1999 b). The site was only surface collected, but it contains flint flakes and Typical Comb Ware with sand temper and the clearly distinctive patterns of geometric decoration typical for the early and high style of the phase (Europaeus-Äyräpää 1930). The site gives an impression of a strong colony (Pesonen 1999 b; also Tallavaara & Pesonen 2020). This conquest of the wilderness was not simply a manifestation of moving into new areas but was a practical response to the climatic optimum vastly increasing the available resources (e.g. seal, birds, fish), particularly on the shores of the Baltic Sea (Tallavaara & Pesonen 2020; Jörgensen et al. 2020; also Nuñez & Okkonen 1999; 2005) but also inland (see Paper III). Apart from the appearance of Corded Ware in the Late Neolithic, the period of Typical Comb Ware is seen much more as a period of population movement than any other period in the Neolithic of eastern Fennoscandia (e.g. Paper III; Meinander 1961; 1984 b; Carpelan 1999). The Typical Comb Ware period also saw an increasing element of eastern hunter-gatherer ancestry in the genetic composition of the area (Saag et al. 2017; Mittnik et al. 2018), which implies migration from the East and Southeast.

Typical Comb Ware is archaeologically very visible because of its pithouses and easily recognisable pottery. Consequently, a large number of radiocarbon dates are available for dating the phase. In the light of Bayesian modelling, the probability distributions for the starting and ending boundaries for Typical Comb Ware are narrower than for other phases with fewer radiocarbon dates (Paper IV: Fig. 3). This is hopefully a situation that will also develop in the future for the other phase models as the number of dates for them increases.

The chronological relationship between Pit-Comb Ware, Rhomb-Pit Ware, and Typical Comb Ware is visualized in Fig. 6.10. In this case, the SPD's of Rhomb-Pit Ware and Typical Comb Ware are largely overlapping, and it is justified to talk about two contemporary ceramic groups. The SPD of Pit-Comb Ware is disturbingly long and overlaps both Typical Comb Ware and Rhomb-Pit Ware, undermining the generally assumed relationship between the styles:

Pit-Comb Ware appears earlier than Typical Comb Ware and Rhomb-Pit Ware, but also survives later than both of these. By taking into account the critical SPD-dates from the Vorob'I 4 site (see Chapter 6.2.2), however, it is possible to evaluate the sequence of Pit-Comb Ware as ending at the same time as Rhomb-Pit Ware. The general relationship of these three pottery types is still far from clear, and more direct dates are needed to clarify the situation, especially for Pit-Comb Ware and Rhomb-Pit Ware. The modelling of these dates would also facilitate their interpretation.

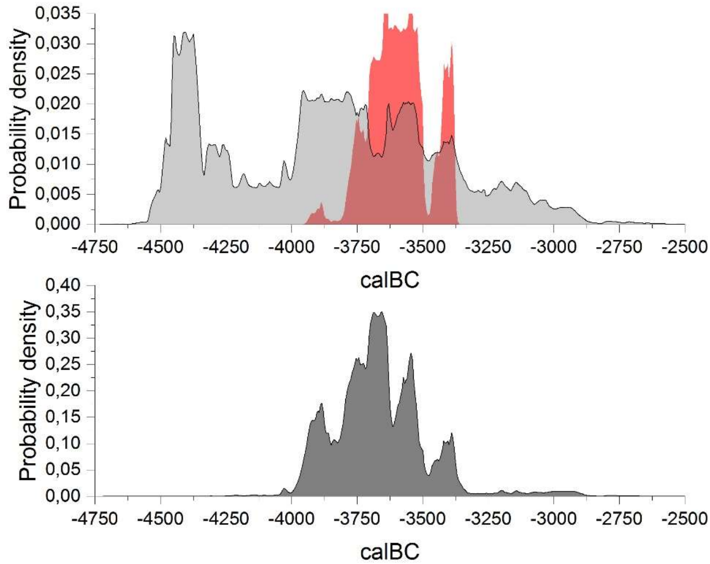

Figure 6.10. A) SPDs of Pit-Comb Ware charred crust radiocarbon dates (grey area, including Vorob'i 4 dates, n= 18) and Rhomb-Pit Ware charred crust dates (red area, n= 10). B) SPD of Typical Comb Ware charred crust (MRE corrected) and birch bark tar dates (n= 94, GrA-63539 excluded).

Late Comb Ware[15] was modelled to 3540–3195 calBC (charred crust and birch bark tar dates). According to these figures it seems possible that Typical and Late Comb Ware may have a chronological overlap with each other. According to the Oxcal modelling, the boundaries for the end of Typical Comb Ware and the beginning of Late Comb Ware are practically contemporaneous. Also, according to the SPDs, the probability densities overlap from ca. 3700 until 3400 calBC, indicating an overlapping period.[16] However, contrary to

[15] Late Comb Ware here includes the possibly earlier and later variants of the type, i.e. Uskela Ware and Sipilänhaka Ware, though the latter probably is not connected to any of the dates.

[16] In addition, Typical Comb Ware has a long tail, extending until ca. 2800 calBC. This tail is due to the effect of two dates: GrA-62507, 4390±60 BP from the Taipalsaari Kujansuu site (Nordqvist 2018) and Hela-3178, 4829±40 BP, MRE corrected 4560±137 BP, from the Nousiainen Kukonharja 2 site (Paper IV).

earlier estimates (e.g. Leskinen 2003; Pesonen & Leskinen 2009), it seems that the oldest dates for Late Comb Ware are quite strongly affected by MRE, and when corrected the overlap is reduced by more than 100 radiocarbon years.

Pyheensilta Ware has practically no radiocarbon dates associated with it, and its position in the chronology is thus based on earlier shore-line chronologies and typological studies (e.g. Meinander 1939; Edgren 1956; Vikkula 1981; 1984; 1987; Asplund 1995; 1997). The Comb Ware continuum from Late Comb Ware to Pyheensilta Ware is by no means assured, as these two ceramic groups display totally different stylistic characteristics, with almost the only common trait being the use of organic temper, which however should not be taken as an indication of belonging to the same tradition but rather as an indication of local knowledge of temper usage (see e.g. Pesonen 2004). Visually, Pyheensilta Ware seems to have more in common with the Pitted Ware distributed along the western coast of the Baltic Sea, and also in the Åland Islands and some specific locations on the eastern coast of the Bothnian Bay (Carpelan 1999; Vikkula 1984; 1987; Asplund 1997; Laulumaa 2005; Miettinen 1999), while still being distinct from it. Previously, the similarity with Volosovo ceramics (Meinander 1984 a; Vikkula 1984) and the Garino-Bor culture (Chalikov 1986) has been singled out, but stressing doubts raised by the geographical distance between the distribution of Pyheensilta Ware and Volosovo potteries (Carpelan 1999; Asplund 1995). However, other potential connections did occur between Middle and Late Neolithic Asbestos and Organic tempered Wares and eastern potteries (Siiriäinen 1984; also Carpelan 1999).

The exact chronological position of Pyheensilta Ware, which sometimes is seen as a continuation of the Comb Ware tradition (e.g. Meinander 1939; Vikkula 1984; Asplund 1997), is not clear, but it is usually placed at the end of the Middle Neolithic and beginning of the Late Neolithic, ca. 3400–2700 calBC (e.g. Nordqvist 2018: Fig. 15), which gives it a chronological contact position with both Late Comb Ware and Corded Ware. The other ceramic types in this same chronological horizon, but with a different geographical distribution, are Orovnavolok and Pöljä Wares, which are found mainly in the eastern and northern parts of eastern Fennoscandia, though not much more north than the Rovaniemi area in Lapland (on the chronology of Orovnavolok Ware, see Nordqvist & Mökkönen 2018; Mökkönen & Nordqvist 2019; Nordqvist 2018: Fig. 15; on the chronology of Pöljä Ware, see e.g. Carpelan 1999; Pesonen 2004; Mökkönen & Nordqvist 2018).

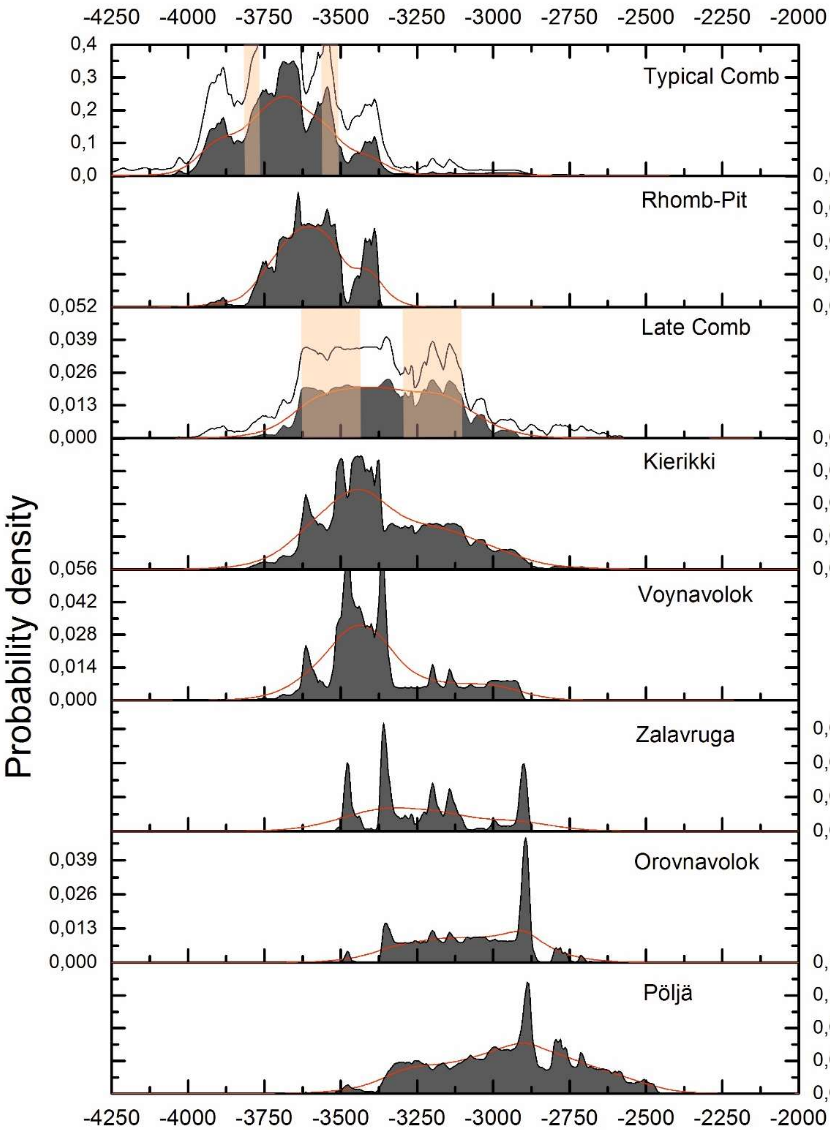

Figure 6.11. Summed probability distributions, kernel density estimates, and modelled boundaries of Middle Neolithic ceramic styles in eastern Fennoscandia. Dark shading indicates a SPD of MRE-corrected charred crust and birch bark tar dates, black lines indicate all the context dates of the specific ceramic style, and the red line kernel density estimate of crust and birch bark tar dates. Vertical bars indicate the mean values of starting and ending boundaries for the styles; the red colour is for boundaries calculated on the basis of charred crust and birch bark tar dates only, the grey colour also includes context dates. The boundaries for Typical and Late Comb Ware are from Paper IV. Typical Comb Ware (n= 94, GrA-63539 excluded Rhomb-Pit Ware (n= 10), Late Comb Ware (n= 12), Kierikki Ware (n= 17), Voynavolok Ware (n= 12), Zalavruga Ware (n= 5), Orovnavolok Ware (n= 6), Pöljä Ware (n= 32). Note: the probability densities are not in the same scale.

The chronological sequences of Middle and Late Neolithic asbestos and organic tempered wares have not yet been updated with Bayesian modelling. The radiocarbon data for some of the pottery types is not comprehensive enough to do so, although Kierikki and Pöljä Wares have accumulated a large number of radiocarbon dates during recent years. Another problem lies in the typological definitions of these ceramics – there are no clear typological guidelines, and the potteries are classified differently in Finland and Russia, leading to a situation where there are effectively two typologies (Nordqvist 2018: 104-111). A third issue is the potential role of reservoir effects, which has not yet been determined for these potteries (cf. Mökkönen & Nordqvist 2018). In this situation, the modelling must wait for the emergence of a coherent typology to work with. SPD's and KDE's indicate that the earliest starting date for Kierikki Ware and Voynavolok Ware is ca. 3700 calBC, while Orovnavolok Ware and Pöljä Ware are younger, starting at 3500 calBC (Fig. 6.11). It is obvious that, along with Kierikki and Voynavolok Wares, Zalavruga Ware was also in use contemporaneously with late Typical Comb Ware and Late Comb Ware. Zalavruga Ware is perhaps best described – at least from its appearance – as a late variant of Typical and/or Late Comb Ware (cf. Nordqvist & Mökkönen 2018: Ris. 5), but its typological and chronological position compared to more western and southern materials has not yet been established. Middle and Late Neolithic asbestos and organic tempered wares and their datings have been discussed recently in other connections (Mökkönen & Nordqvist 2018; Nordqvist & Mökkönen 2018; Tarasov et al. 2017).

6.2.4 LATE NEOLITHIC CERAMICS IN EASTERN FENNOSCANDIA

The chronology of Corded Ware is quite well established for its beginning phase ca. 2900 calBC in eastern Fennoscandia (Fig. 6.12; Paper V; Mökkönen 2011a; Nordqvist 2016), and its appearance is related to a migration originating in the Steppe regions of southeastern Europe (e.g. Allentoft et al. 2015; Haak et al. 2015; Saag et al. 2017; Jones et al. 2017; Mittnik et al. 2018). Earlier time-estimates placing its starting point as early as 3200 calBC (e.g. Carpelan 1999; Pesonen & Leskinen 2009) made it difficult to position the phase not only within the wider view of European prehistory, but also within eastern Fennoscandian prehistory. For example, the modelling placed the end of Late Comb Ware at 3195±100 calBC, thus indicating that these two ceramic phases did not overlap chronologically (Papers IV and V), making the discussion of the possible mixing of these traditions outdated, at least for the area of Finland (cf. Carpelan 1999: 262; Edgren 1970; 1997; 1999).[17] The situation may have been different in the Karelian Isthmus and Estonia due to

[17] For more discussion see Mökkönen 2008: 137-142; the gap between the end of Late Comb Ware and the beginning of Corded Ware in Finland has also been noted by Nordqvist 2016: 53-54.

the longer duration of Late Comb Ware (Lang & Kriiska 2001: 92; Kholkina 2018), and it has even been suggested that there were hybrid forms of Late Comb Ware and Corded Ware (Kholkina 2017).

The possible connections between the “inlanders” producing Pöljä Ware and the “southerners” producing Corded Ware has also been discussed (e.g. Äyräpää 1952; Edgren 1997; 1999: 290; Nordqvist 2018: 112), but the simultaneous appearance of these two groups apparently did not led to any material culture manifestations other than the so-called barbaric imitations of battle axes (Äyräpää 1952). However, the unrest hypothesized on the basis of the appearance of megastructure sites (fi. *jätinkirkko*) coincides roughly with that of the appearance of Corded Ware on the shores of the Baltic Sea in Northern Ostrobothnia – in the same area where Pöljä Ware was also present at that time (Tallavaara & Pesonen 2020; Pesonen et al. 2020; Okkonen 2003; Nuñez & Okkonen 1999; 2005; Lahelma & Sipilä 2004; Sipilä & Lahelma 2006; Halinen 2015: 118). This is clearly a matter for further micro-regional studies.

The later phase of Corded Ware in eastern Fennoscandia is poorly understood, but the culture bearing this pottery seems to have gone through some sort of slow fading process in several parts of the area, e.g. in the eastern part of Gulf of Finland, where many late radiocarbon dates indicate its use even until the beginning of the 2nd millennium calBC (Nordqvist 2016: 61), and in south-central Finland, where the local adaptation of Corded Ware manifests as so-called Middle Zone ceramics (Carpelan 1979; Nordqvist 2016: 60). In the study material of this dissertation, the end of Corded Ware is placed at 2200 calBC (Paper V). The long chronology of Corded Ware is taken as an indication of the continuation of settlement into the Final Neolithic and Bronze Age, similar to the situation that has been interpreted in Estonia (see Kriiska & Tvauri 2007; Lang 2007; Nordqvist 2016: 61). There is no reason to object to this reasoning, but the matter should also be studied in the future through the chronological modelling of radiocarbon dates for the Late and Final Neolithic and Bronze Age contexts. In this context Kiukainen Ware, Pöljä Ware, and textile ceramics (Sarsa-Tomitsa group) are of special interest (cf. Asplund 2008; Lavento 2001; 2012).

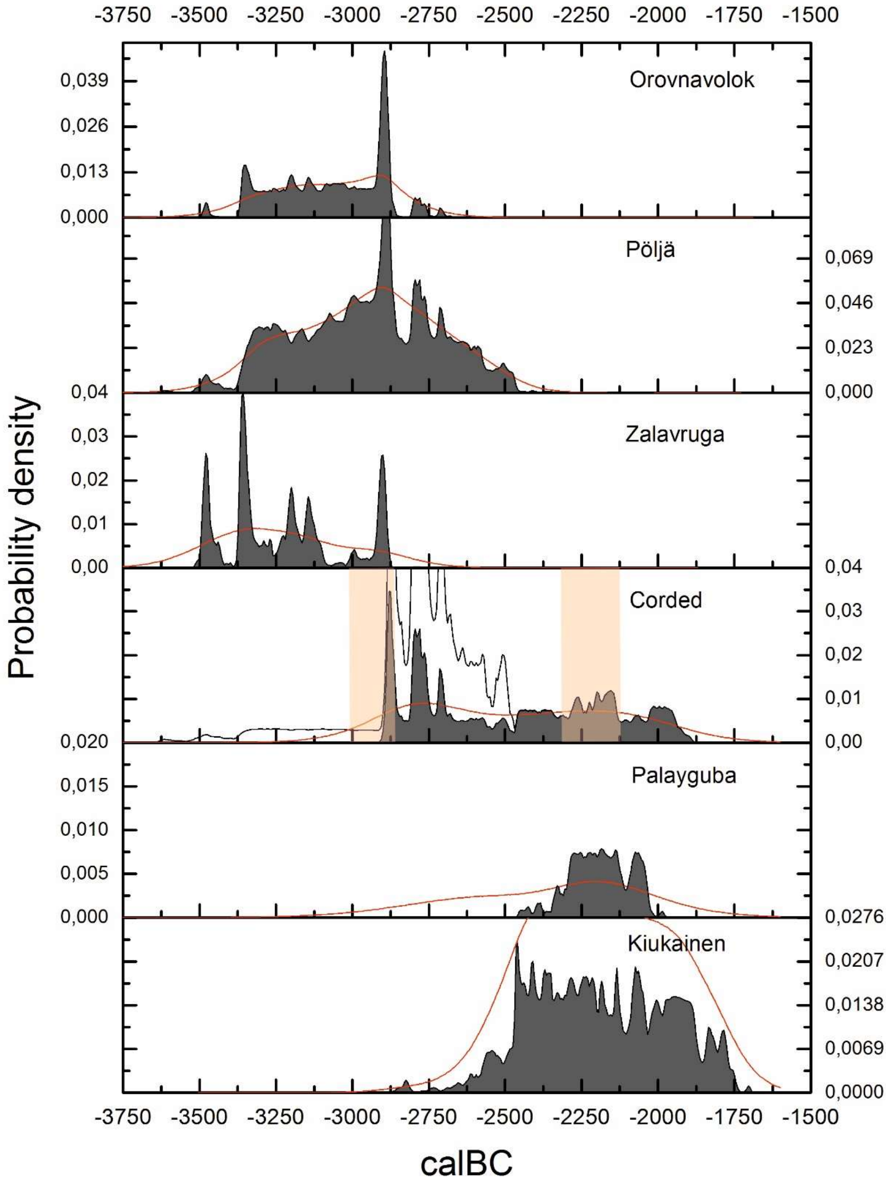

Figure 6.12. Summed probability distributions, kernel density plots, and modelled boundaries for the Late Middle, Late, and Final Neolithic ceramic styles in eastern Fennoscandia. Dark shading indicates SPD of MRE-corrected charred crust and birch bark tar dates, black lines indicate the use of all the context dates for the specific ceramic style, and the red line the kernel density estimate of crust and birch bark tar dates. Vertical bars indicate the mean values of the starting and ending boundaries for the styles, the red colour is for boundaries calculated on basis of charred crust and birch bark tar dates only, while the grey colour also includes context dates. The boundaries for Corded Ware are from Paper V. Orovnavolok Ware (n= 6), Pöljä Ware (n= 32), Zalavruga Ware (n= 5), Corded Ware (n= 8), Palayguba Ware (n= 3), Kiukainen Ware (n= 11). Note: the probability densities are not in the same scale.

7 CONCLUSIONS

My main ambition during this dissertation process has been to try to establish a quantitatively coherent chronology of the Neolithic in eastern Fennoscandia. As pottery is one of the primary artefact types of the Neolithic, having varied decorative patterns that can be analysed stylistically as well as being able to be directly dated via charred crust and birch bark tar, the focus of the chronology building has been on pottery. The Eastern Fennoscandian Neolithic is divided into Early, Middle, Late, and Final Neolithic stages, of which my work deals mainly with the Early and Middle Neolithic.

An issue that repeats itself constantly in the work is the identification of the continuity and discontinuity of archaeological cultures, or the traditions carried by people. The rapid dispersion of artefact types over large areas can be interpreted as the effect of a wide-scale migration, of which two cases in eastern Fennoscandia now seem to be confirmed by aDNA-studies: those of the dispersion of Typical Comb Ware and Corded Ware. I find it plausible that these rapid dispersions were primarily caused by migrations, while the slower dispersions of other artefact types and styles may have been caused by shared societal networks diffusing commodities at a slower pace. It is possible to study these types of cultural continuity, discontinuity, and contemporaneity with the help of statistical tools, which has been my aim to demonstrate with this work.

Methodologically, the work applies different analytical tools and visualizations implemented within a Bayesian statistical framework. Bayesian modelling performed with the Oxcal radiocarbon calibration programme is the most important and prevalent tool in the work. The method provides quantitatively coherent and updatable estimates for phase boundaries, and these are complemented by summed probability distributions (SPD) and kernel density estimates (KDE). In this work charred crust and birch bark tar dates and context dates from (Early Neolithic) Säräisniemi 1 Ware, Sperrings 1 Ware, Sperrings 2 Ware, Early Asbestos Ware, Jäkärlä Ware, (Middle Neolithic) Typical Comb Ware, Late Comb Ware, and (Late Neolithic) Corded Ware were evaluated thoroughly with modelling tools and then further analysed with SPDs and KDEs. In addition, the available (Early Neolithic) Pit-Comb Ware, (Middle Neolithic) Rhomb-Pit Ware, Kierikki Ware, Pöljä Ware, Orovnavolok Ware, Voynavolok Ware, Zalavruga Ware, (Late Neolithic) Palayguba Ware, and (Final Neolithic) Kiukainen Ware charred crust and birch bark tar dates were studied with SPDs and KDEs. The modelled phase boundaries of charred crust and birch bark tar dates provide the most accurate estimate of the actual use periods of the potteries, while SPDs provide a visualization of the sequence and KDE-plotting smooths the peaks and valleys caused by the calibration curve. In several cases, the context dates are still needed for quantitative estimates because of the small amount of direct charred crust and birch bark tar dates. More of these dates are needed in order to establish a coherent chronology for the Neolithic in eastern Fennoscandia. Judging from the experience gained during this dissertation process, these models work better with a large number of dates. Ideally, there should be at least 10-15 radiocarbon dates to build a reliable model – otherwise the error margins of the starting and ending boundaries tend to remain too wide.

The use of charred crust radiocarbon dates involves the potential of marine reservoir effect (MRE), and possibly in some cases freshwater reservoir effect (FRE) as well, but so far the latter has not been considered significant in eastern Fennoscandian environmental conditions. In this work, I have estimated MRE according to stable carbon isotope values (Paper II; Paper IV; Paper V). With this method, the marine samples that have the most potential to affect the dating process are accounted for, and the role of MRE in establishing chronological estimates is thus reduced.

The subject of this dissertation, establishing the chronology of the ceramic production phases of the eastern Fennoscandian Neolithic through Bayesian inference, has identified several points of time that can be interpreted as points of disruption – if not even points of disconnection – and which can be discussed within these terms. These points are: 1) the termination of pottery production in the northern parts of eastern Fennoscandia at the end of the Early Neolithic, 2) the end of Sperrings 2 Ware in the Early Neolithic, 3) the end of Jäkärlä Ware in southwestern Finland, 4) the end of Early Asbestos Ware in eastern Finland, 5) the arrival of Typical Comb Ware, and 6) the arrival of Corded Ware.

There are also a number of points that I would rather interpret as signs of continuity on the basis of both typological indifference and strong overlaps in the Bayesian models: 1) the adoption of ceramics in the form of Säräisniemi 1 and Sperrings 1 Wares in eastern Fennoscandia, and later also the beginning of the production of Jäkärlä and Early Asbestos Wares; 2) the continuity between Sperrings 1 and Sperrings 2 Wares; 3) the continuity between Typical and Late Comb Ware; and 4 & 5) – themes not discussed in any of the papers, but briefly touched upon in the dissertation – the continuity after the Middle and Late Neolithic, after the time of Late Comb Ware and after Corded Ware.

In the future, when new radiocarbon dates are available, it will be possible – and indeed necessary - to update these models. In fact, this is one of the main assets of Bayesian modelling: our working knowledge can be updated based on new information. Potential outlier dates can also be more accurately detected when larger amounts of data become available, allowing researchers to either reject them or adjust their weight within the models. With more knowledge of the Holocene history of the seas and lakes and their radiocarbon content through time, it will also be possible to better understand the reservoir effects affecting the radiocarbon dates. This is one of central problems to be solved for the area of eastern Fennoscandia, for example with a paired dating programme. Another goal for the future should also be the compound-specific dating of lipid remains in pottery, which will additionally yield more information on the diet of the hunter-fisher-gatherers in eastern Fennoscandia over time.

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Appendix I. Radiocarbon dates used in Papers II-V.

Abbreviations. Cultural context: CW = Corded Ware, EAW = Early Asbestos Ware, TCW = Typical Comb Ware, LCW = Late Comb Ware, UCW = unidentified Comb Ware, Jäk = Jäkärlä Ware, Sär 1 = Säräisniemi 1 Ware, Spr 1 = Sperrings 1 Ware, Spr 2 = Sperrings 2 Ware. Country: FIN = Finland, NOR = Norway, RUS = Russia. Material: bone = burnt bone, coal = charcoal, ccr = charred crust, bbt = birch bark tar, nut = charred nutshell, bark = birch bark (house remain). MRE corrected dates in bold.

Cultural context	Country	Municipality	Site	Labcode	Paper II	Paper III	Paper IV	Paper V	C14 Age BP	C14 Age error	δ13C	MRE corrected BP	MRE corr. Error	Material	Context	Reference	Catalogue number
CW	FIN	Vantaa	Jönsas	Hel-1006				x	4520	130		4520	130	coal	burial	Ojonen 1983	
CW	FIN	Seinäjoki	Isosaari	Hela-2658				x	4229	47	-24,70	**4184**	**52**	ccr	pottery (CW)	Paper IV	
CW	FIN	Teuva	Kortesnevankangas	Hela-3429				x	4216	28	-28,00	4216	28	ccr	pottery (CW)	Holmqvist et al. 2018	KM 18921
CW	FIN	Porvoo	Böle	Hela-3426				x	4210	29	-26,40	4210	29	ccr	pottery (CW)	Holmqvist et al. 2018	KM 22004:6006
CW	FIN	Kirkkonummi	Tengo Nyåker	Hela-3461				x	4205	31	-25,90	4205	31	bone		Holmqvist et al. 2018	KM 21501:51
CW	FIN	Halikko	Urheilutie 15	Hela-3458				x	4192	28	-28,00	4192	28	bone		Holmqvist et al. 2018	KM 22008:144
CW	FIN	Vantaa	Vanha Nurmijärventie	Ua-32204				x	4185	45	-27,00	4185	45	bone		Leskinen & Pesonen 2008	
CW	FIN	Vantaa	Hommas	Hela-1648				x	4165	40	-27,30	4165	40	bone		Koivisto 2010	
CW	FIN	Tammela	Uusi-Markkula	Hela-3462				x	4161	31	-27,60	4161	31	bone		Holmqvist et al. 2018	KM 37643:495
CW	FIN	Porvoo	Forsberg	Sch156/H1938-1009				x	4140	80		4140	80	coal	burial	Edgren 1992	
CW	FIN	Virolahti	Mattilan VPK	Hela-3428				x	4136	29	-23,50	**4050**	**51**	ccr	pottery (CW)	Holmqvist et al. 2018	KM 15329:132
CW	FIN	Porvoo	Forsberg	GrN-6256				x	4105	55		4105	55	coal	burial	Edgren 1992	
CW	FIN	Halikko	Urheilutie 15	Hela-3457				x	4040	30	-26,90	4040	30	bone		Holmqvist et al. 2018	KM 22008:202
CW	FIN	Espoo	Mäntymäki	Hela-3425				x	3897	29	-28,90	3897	29	ccr	pottery (CW)	Holmqvist et al. 2018	KM 16288:16

CW	FIN	Virolahti	Meskäärtty	Hela-1614				x	3820	45	-25,00	**3786**	**48**	ccr	pottery (CW)	Mökkönen 2008	
CW	FIN	Vantaa	Jönsas	Ua-32196				x	3790	40	-25,20	**3763**	**42**	ccr	pottery (CW)	Leskinen & Pesonen 2008	KM 20087:264
CW/ TCW	FIN	Lieto	Kukkarkoski I	Hel-831			x	x	4320	170		4320	170	coal	burial	Torvinen 1979	
EAW	FIN	Kontiolahti	Nekkilänaho 2	Hela-2572		x			5812	37	-26,00	5812	37	bone	mammal + indet. Bone	Paper III	
EAW	FIN	Rääkkylä	Kivilamminsuo	Hela-2938		x			5787	41	-28,30	5787	41	bone	elk bone	Paper III	KM 28774:6
EAW	FIN	Outokumpu	Sätös	Hela-2560		x			5728	46	-31,10	5728	46	bone	beaver bone	Paper III	
EAW	FIN	Rääkkylä	Pörrinmökki	Hel-3224		x			5640	100	-25,70	5640	100	coal		Pesonen 1996e	
EAW	FIN	Liperi	Väinölä	Hela-2577		x			5612	45	-28,20	5612	45	bone	mammal bone	Paper III	
EAW	FIN	Kitee	Sarvisuo	Su-2478		x			5440	40		5440	40	coal	fireplace	Pesonen 2001	
EAW	FIN	Lappeenranta	Saksanniemi	Hela-2871		x			5421	38	-27,00	5421	38	bbt	pottery (EAW)	Paper III	KM 12169:75
EAW	FIN	Outokumpu	Lintutorni	Hel-4128		x			5350	90	-25,40	5350	90	coal		Karjalainen 2002	
EAW	FIN	Vieremä	Hukkalanharju	Hel-800		x			5330	150		5330	150	coal		Pohjakallio 1984	
EAW	FIN	Kitee	Sarvisuo	Hela-2937		x			5286	40	-28,00	5286	40	bone	mammal bone	Paper III	KM 29714:769
EAW	FIN	Rääkkylä	Pörrinmökki	Hel-3222		x			5270	100	-26,00	5270	100	coal		Pesonen 1996e	
EAW	FIN	Liperi	Kyläsärkkä	Hela-2872		x			5259	39	-25,10	5259	39	ccr	pottery (EAW)	Paper III	KM 23111:69
EAW	FIN	Rääkkylä	Vihi 1	Hela-2939		x			5242	40	-26,60	5242	40	bone	mammal bone	Paper III	KM 30460:11817
EAW	FIN	Jyväskylä	Raidanlahti	Hel-127		x			5240	190		5240	190	coal		Junno et al. 2015	
EAW	FIN	Kitee	Hiekanpää I	Hela-1017		x			5240	40	-28,50	5240	40	bone	mammal bone	Paper III	
EAW	FIN	Rääkkylä	Lappalaissuo	Hela-2875		x			5206	41	-30,50	5206	41	bbt	pottery (EAW)	Paper III	KM 27572:1
EAW	FIN	Outokumpu	Sätös	Hela-2816		x			5205	46	-27,60	5205	46	bone		Paper III	
EAW	FIN	Vieremä	Hukkalanharju	Hel-799		x			5180	140		5180	140	coal		Pohjakallio 1984	KM 27818:4
EAW	FIN	Kitee	Hiekanpää III	Hela-2936		x			5167	39	-28,00	5167	39	bone	reindeer bone	Paper III	KM 27818
EAW	FIN	Kitee	Karistaja	Hela-1290		x			5155	40	-26,20	5155	40	coal		Paper III	
EAW	FIN	Rääkkylä	Pörrinmökki	Hel-3223		x			5090	100	-25,70	5090	100	coal		Pesonen 1996e	
EAW	FIN	Nilsiä	Lohilahti	Hela-2941		x			5083	40	-26,90	5083	40	bone	beaver bone	Paper III	KM 33378:116,124
EAW	FIN	Punkaharju	Pusunlahti	Hela-2935		x			5081	40	-28,30	5081	40	bone	mammal bone	Paper III	KM 26804:24
Jäk	FIN	Mynämäki	Aisti	Hela-3075			x		7450	49	-27,10	7450	49	ccr	pottery (Jäkärlä)	Paper IV	KM 15133:5
Jäk	FIN	Sauvo	Nummenharju	Hel-48			x		5990	180		5990	180	coal	fireplace	Meinander 1971	KM 17066:169
Jäk	FIN	Eura	Kolmhaara	Hel-4612			x		5850	90	-25,40	5850	90	coal	fireplace	Paper IV	

Jäk	FIN	Sauvo	Nummenharju	Hel-46			x		5820	140		5820	140	coal	fireplace	Meinander 1971	KM 16735:137
Jäk	FIN	Sauvo	Nummenharju	Hel-47			x		5740	160		5740	160	coal	fireplace	Meinander 1971	KM 16735:66
Jäk	FIN	Sauvo	Nummenharju	Hel-45			x		5490	160		5490	160	coal	fireplace	Meinander 1971	KM 16735:10
Jäk	FIN	Sauvo	Nummenharju	Hel-44			x		5300	160		5300	160	coal	fireplace	Meinander 1971	KM 16735:87
Jäk	FIN	Nousiainen	Kukonharju 2	Hela-2660			x		5230	41	-20,80	**5051**	**97**	ccr	pottery (Jäkärlä)	Paper IV	
Jäk	FIN	Raasepori	Telegrafberget	Hela-3168			x		5211	40	-26,80	5211	40	ccr	pottery (Jäkärlä)	Paper IV	KM 32553:6
Jäk	FIN	Espoo	Mynt	Hela-3166			x		5210	40	-26,20	5210	40	ccr	pottery (Jäkärlä)	Paper IV	KM 14594:392
Jäk	FIN	Turku	Jäkärlä	Ua-46150			x		5195	56		5195	56	ccr	pottery (Jäkärlä)	Pääkkönen et al. 2016	
Jäk	FIN	Nousiainen	Rauanniittu	Hel-2662			x		5190	110	-25,80	5190	110	coal	fireplace	Paper IV	
Jäk	FIN	Nousiainen	Kukonharju 2	Hela-2661			x		5177	37	-19,50	**4953**	**116**	ccr	pottery (Jäkärlä)	Paper IV	
Jäk	FIN	Kemiönsaari	Nöjis	Hel-2821			x		5160	120	-23,60	5160	120	coal	cultural layer?	Asplund 1995	TYA 471:81
Jäk	FIN	Lieto	Kukkarkoski II	Hela-3176			x		5130	40	-25,00	**5096**	**43**	ccr	pottery (Jäkärlä)	Paper IV	KM 16879:161
Jäk	FIN	Turku	Jäkärlä	Hela-3169			x		5119	42	-26,80	5119	42	ccr	pottery (Jäkärlä)	Paper IV	KM 8063:107
Jäk	FIN	Mynämäki	Aisti	Hela-3076			x		5055	41	-26,10	5055	41	ccr	pottery (Jäkärlä)	Paper IV	KM 16078:6
Jäk	FIN	Turku	Jäkärlä	Hel-2420			x		5050	140	-24,50	5050	140	coal	cultural layer	Junno et al. 2015	
Jäk	FIN	Nousiainen	Rauanniittu	Hel-2664			x		5040	110	-25,50	5040	110	coal	fireplace	Paper IV	
Jäk	FIN	Kemiönsaari	Nöjis	Hel-2820			x		5040	120	-24,10	5040	120	coal	cultural layer?	Asplund 1995	TYA 471:76
Jäk	FIN	Sauvo	Nummenharju	Hel-63			x		5020	180		5020	180	coal	cultural layer?	Meinander 1971	KM 16735:268
Jäk	FIN	Lieto	Merola	Hela-3172			x		5002	40	-25,70	**4992**	**40**	ccr	pottery (Jäkärlä)	Paper IV	KM 16879:28
Jäk	FIN	Kemiönsaari	Nöjis	Hel-2819			x		4960	130	-25,10	4960	130	coal	cultural layer?	Asplund 1995	TYA 471:60
Jäk	FIN	Sauvo	Nummenharju	Hela-3165			x		4926	35	-12,70	4926	35	bone	seal bone	Paper IV	KM 16735:291
Jäk	FIN	Nousiainen	Rauanniittu	Hel-2663			x		4900	110	-24,20	4900	110	coal	fireplace	Paper IV	
Jäk	FIN	Kemiönsaari	Nöjis	Hel-2817			x		4740	130	-26,90	4740	130	coal	cultural layer?	Asplund 1995	TYA 471:16
Jäk	FIN	Kemiönsaari	Nöjis	Hel-2818			x		4710	120	-24,70	4710	120	coal	cultural layer?	Asplund 1995	TYA 471:35
Jäk	FIN	Kemiönsaari	Nöjis	Hel-2815			x		4530	130	-22,90	4530	130	coal	cultural layer?	Asplund 1995	TYA 327:15
Jäk	FIN	Kemiönsaari	Nöjis	Hel-2816			x		4490	120	-25,50	4490	120	coal	cultural layer?	Asplund 1995	TYA 471:8
Kier	FIN	Lappeenranta	Ahvensaari	Hela-360		x			4450	60	-28,70	4450	60	ccr	pottery (Kierikki)	Pesonen 2004	
LCW	FIN	Vantaa	Maarinkunnas	Hela-259			x		4940	70	-22,30	**4812**	**93**	ccr	pottery (LCW)	Leskinen 2003	KM 30464:1249
LCW	FIN	Laitila	Nästinristi	Hel-1349			x		4900	130		4900	130	coal	burial	Junno et al. 2015	KM 20606
LCW	FIN	Humppila	Järvensuo	Hel-1696			x		4870	120		4870	120	coal	gyttja layer?	Junno et al. 2015	KM 21493c

LCW	FIN	Laitila	Nästinristi	Hel-1350			x		4840	130		4840	130	coal	burial	Junno et al. 2015	KM 20606
LCW	FIN	Vantaa	Maarinkunnas	Hela-257			x		4835	70	-24,10	**4769**	**76**	ccr	pottery (LCW)	Leskinen 2003	KM 30464:9427
LCW	RUS	Kaukola	Kyöstälänharju	Hela-359			x		4780	70	-27,50	4780	70	bbt	pottery (LCW)	Pesonen 2004	KM 5699:9
LCW	FIN	Nousiainen	Kuuvanvuori	Hela-979			x		4775	55	-22,80	**4664**	**76**	ccr	pottery (LCW)	Paper IV	KM 35020:83
LCW	FIN	Laitila	Nästinristi	Hel-1346			x		4730	100		4730	100	coal	fireplace	Junno et al. 2015	KM 20606
LCW	FIN	Vantaa	Maarinkunnas	Hela-258			x		4710	75	-22,90	**4603**	**91**	ccr	pottery (LCW)	Leskinen 2003	KM 30464:13811
LCW	FIN	Laitila	Nästinristi	Hel-1347			x		4700	100		4700	100	coal	fireplace	Junno et al. 2015	KM 20606
LCW	FIN	Helsinki	Kårböle folkskola	Hela-160			x		4680	60	-26,40	4680	60	nut		Lesell 2005	
LCW	FIN	Vantaa	Maarinkunnas	Hela-254			x		4680	80	-28,30	4680	80	bbt	pottery (LCW)	Leskinen 2003	KM 30464:10801
LCW	FIN	Helsinki	Kårböle folkskola	Hela-159			x		4620	65	-25,10	**4589**	**66**	ccr	pottery (LCW)	Lesell 2005	
LCW	FIN	Jomala	Jettböle Bergmanstorp	Ua-15869			x		4560	80	-27,70	4560	80	ccr	pottery (LCW)	Stenbäck 2003	ÅM 696: 80
LCW	FIN	Vantaa	Sandåker	Ua-33680			x		4555	40	-14,00	4555	40	bone	porpoise bone	Leskinen & Pesonen 2008	KM 28203: 3239
LCW	RUS	Viipuri	Häyrynmäki	Hela-358			x		4550	60	-26,50	4550	60	bbt	pottery (LCW)	Pesonen 2004	KM 5620:CCXLIV
LCW	FIN	Kristiinankaupunki	Rävåsen	Hela-461			x		4545	70	-26,70	4545	70	nut		Hertell & Manninen 2006	
LCW	FIN	Virolahti	Meskäärtty	Hela-1613			x		4535	35	-25,10	**4504**	**38**	ccr	pottery (LCW)	Mökkönen 2008	
LCW	FIN	Virolahti	Meskäärtty	Hela-1615			x		4520	40	-27,50	4520	40	ccr	pottery (LCW)	Mökkönen 2008	
LCW	FIN	Laitila	Nästinristi	Hel-1348			x		4450	130		4450	130	coal	burial	Junno et al. 2015	KM 20606
LCW	FIN	Kristiinankaupunki	Rävåsen	Hela-336			x		4440	75	-26,20	4440	75	coal	burial	Miettinen 2005	KM 30588:3115
LCW	FIN	Kristiinankaupunki	Byåsen	Hela-1532			x		4430	40	-26,10	4430	40	ccr	pottery (LCW)	Paper IV	KM 36485:149
LCW	FIN	Kokkola	Bläckisåsen	Su-1568			x		4200	60	-26,00	4200	60	coal	cultural layer	Paper IV	
Spr 1	RUS		Sulgu 2	KIA-35900			x		6670	35		6670	35	bone	elk/reindeer bone	Piezonka 2008	
Spr 1	RUS		Pegrema 9	TA-1161			x		6510	90		6510	90	coal	fireplace	Timofeev et al. 2004	
Spr 1	RUS		Khepojarvi	Le-1412			x		6480	60		6480	60	coal	fireplace	Timofeev et al. 2004	
Spr 1	RUS		Sheltozero 11	TA-1312			x		6480	70		6480	70	coal	cultural layer	Timofeev et al. 2004	
Spr 1	RUS		Shettima 1	TA-1552			x		6400	150		6400	150	coal	fireplace	Timofeev et al. 2004	
Spr 1	RUS		Khepojarvi	Le-1411			x		6380	60		6380	60	coal	fireplace	Timofeev et al. 2004	

Spr 1	RUS		Vozmaricha 26	Le-6799			x		6370	140		6370	140	coal	cultural layer	Piezonka 2008	
Spr 1	FIN	Kontiolahti	Erolanniemi 1	Hela-2557		x	x		6267	44	-28,30	6267	44	bone	burnt bone	Paper III	KM 38268:105
Spr 1	FIN	Pieksämäki	Marketanhiekka	Hel-4578			x		6240	100	-24,60	6240	100	coal	stone structure	Paper IV	
Spr 1	RUS		Uya III	GrA-63566			x		6225	40	-28,26	6225	40	ccr	pottery (Spr 1)	Nordqvist & Mökkönen 2016a	
Spr 1	FIN	Saltvik	Östra Jansmyra I	Ua-17856	x		x		6186	120	-26,80	6186	120	ccr	pottery (Spr 1)	Stenbäck 2003	ÅM 635: 1
Spr 1	RUS		Veksa 3	KIA-33927	x		x		6185	30	-30,26	6185	30	ccr	pottery (Spr 1)	Piezonka 2008	
Spr 1	FIN	Vantaa	Etelä-Vantaa 1-2	Ua-32200			x		6180	55	-25,60	6180	55	bone	seal bone	Leskinen & Pesonen 2008	KM 18470:364
Spr 1	FIN	Saltvik	Vargstensslätten II	Ua-17859	x		x		6165	75	-26,40	6165	75	ccr	pottery (Spr 1)	Stenbäck 2003	ÅM 472: 483
Spr 1	RUS		Uya III	GrA-63581			x		6160	40	-26,63	6160	40	paint	pottery (Spr 1)	Nordqvist & Mökkönen 2016a	
Spr 1	FIN	Kitee	Koivikko	Hela-2953		x	x		6117	44	-30,10	6117	44	ccr	pottery (Spr 1)	Oinonen et al. 2014	KM 13014
Spr 1	FIN	Saltvik	Östra Jansmyra I	Ua-17854	x		x		6100	75	-25,70	**6090**	**75**	ccr	pottery (Spr 1)	Stenbäck 2003	ÅM 115: 51
Spr 1	FIN	Pieksämäki	Marketanhiekka	Hel-4564			x		6090	100	-24,20	6090	100	coal	ceramic concentration	Paper IV	
Spr 1	RUS		Sulgu 2	KIA-36724	x		x		6085	30		6085	30	ccr	pottery (Spr 1)	Piezonka 2008	
Spr 1	RUS		Tudozero 5	Le-6699			x		6075	20		6075	20	coal	fireplace	Timofeev et al. 2004	
Spr 1	FIN	Saltvik	Östra Jansmyra I	Ua-17855	x		x		6065	80	-24,80	**6024**	**82**	ccr	pottery (Spr 1)	Stenbäck 2003	ÅM 635: 1
Spr 1	FIN	Lieksa	Haasiinniemi	Hel-3307			x		6060	120	-25,60	6060	120	coal	fireplace	Katiskoski 1996	
Spr 1	FIN	Kouvola	Ankkapurha	Hela-395	x		x		6060	60	-26,50	6060	60	ccr	pottery (Spr 1)	Schulz 2004	KM 31785:1279
Spr 1	FIN	Kokemäki	Kraviojankangas	Hel-1380			x		6050	170		6050	170	coal	fireplace	Nuñez 1990	
Spr 1	RUS		Sulgu 2	KIA-33925	x		x		6015	30	-26,48	6015	30	bbt	pottery (Spr 1)	Piezonka 2008	
Spr 1	FIN	Kokemäki	Kraviojankangas	Ua-46149			x		5992	35		5992	35	ccr	pottery (Spr 1)	Pääkkönen et al. 2016	
Spr 1	RUS		Erpin Pudas 1	TA-779			x		5990	100		5990	100	coal	fireplace	Timofeev et al. 2004	
Spr 1	FIN	Saltvik	Vargstensslätten II	Ua-17857	x		x		5990	90	-25,80	**5983**	**90**	ccr	pottery (Spr 1)	Stenbäck 2003	ÅM 472: 180
Spr 1	FIN	Saltvik	Vargstensslätten II	Ua-17858	x		x		5990	75	-25,50	**5973**	**75**	ccr	pottery (Spr 1)	Stenbäck 2003	ÅM 472: 222
Spr 1	FIN	Saarijärvi	Rusavierto	Hela-442	x		x		5985	80	-27,90	5985	80	ccr	pottery (Spr 1)	Leskinen 2002	KM 32195: 247
Spr 1	FIN	Utajärvi	Roinila	Hela-149	x		x		5975	105	-25,60	**5961**	**105**	ccr	pottery (Spr 1)	Hallgren 2004	KM 13600:3+5
Spr 1	RUS		Uya III	GrA-63546			x		5970	40	-28,77	5970	40	bbt	pottery (Spr 1)	Nordqvist & Mökkönen 2016a	
Spr 1	RUS		Sheltozero 11	TA-1313			x		5960	70		5960	70	coal	cultural layer	Timofeev et al. 2004	

Spr 1	FIN	Vantaa	Silvola	Ua-32199			x		5950	50	-22,60	5950	50	bone	seal bone	Leskinen & Pesonen 2008	KM 11156: 41
Spr 1	RUS		Orovnavolok V	GrA-63735			x		5945	40	-27,23	5945	40	bbt	pottery (Spr 1)	Nordqvist & Mökkönen 2016a	
Spr 1	FIN	Simo	Tainiaro	Hela-80	x		x		5940	100	-27,60	5940	100	ccr	pottery (Spr 1)	Hallgren 2004	KM 22398:342
Spr 1	FIN	Vantaa	Etelä-Vantaa 3	Ua-32194	x		x		5925	45	-24,80	**5884**	**49**	ccr	pottery (Spr 1)	Leskinen & Pesonen 2008	KM 18978: 106
Spr 1	FIN	Simo	Tainiaro	Hela-79	x		x		5920	100	-28,60	5920	100	ccr	pottery (Spr 1)	Hallgren 2004	KM 22398:349
Spr 1	FIN	Porvoo	Böle	Hela-3177			x		5884	43	-26,00	5884	43	ccr	pottery (Spr 1)	Paper IV	KM 17074:724
Spr 1	RUS		Sheltozero 5	GrA-63587			x		5870	40	-27,20	5870	40	ccr	pottery (Spr 1)	Nordqvist & Mökkönen 2016a	
Spr 1	FIN	Vantaa	Viinikkala 2	Hela-887	x		x		5865	55	-26,00	5865	55	ccr	pottery (Spr 1)	Leskinen & Pesonen 2008	KM 34277:81
Spr 1	RUS		Erpin Pudas 1	TA-472			x		5860	100		5860	100	coal	cultural layer?	Timofeev et al. 2004	
Spr 1	FIN	Saarijärvi	Rusavierto	Su-2718			x		5850	50	-25,10	5850	50	coal	cultural layer	Leskinen 2002	
Spr 1	RUS		Orovnavolok V	TA-2265			x		5850	80		5850	80	coal	fireplace	Timofeev et al. 2004	
Spr 1	FIN	Simo	Tainiaro	Hel-2109			x		5840	100		5840	100	coal	burial	Junno et al. 2015	
Spr 1	FIN	Kontiolahti	Erolanniemi 1	Hela-2556		x	x		5839	46	-26,30	5839	46	bone	burnt bone	Paper III	KM 38268:50
Spr 1	RUS	Uusikirkko	Kelonen	GrA-63528			x		5835	40	-26,63	5835	40	ccr	pottery (Spr 1)	Nordqvist & Mökkönen 2016a	KM 8699:53
Spr 1	FIN	Kokemäki	Kraviojankangas	Ua-46148			x		5831	36		5831	36	ccr	pottery (Spr 1)	Pääkkönen et al. 2016	
Spr 1	RUS	Muolaa	Telkkälä	Hela-554	x		x		5830	80	-27,50	5830	80	ccr	pottery (Spr 1)	Takala & Sirviö 2003	
Spr 1	RUS		Erpin Pudas 1	TA-413			x		5825	80		5825	80	coal	cultural layer?	Timofeev et al. 2004	
Spr 1	FIN	Lappeenranta	Etu- ja Taka-Muntero	Hela-2295		x	x		5818	41	-26,20	5818	41	bone	mammal bone	Paper III	KM 37988:205
Spr 1	FIN	Vantaa	Viinikkala 2	Hela-886	x		x		5805	50	-25,90	**5802**	**50**	ccr	pottery (Spr 1)	Leskinen & Pesonen 2008	KM 34277:58
Spr 1	FIN	Kouvola	Ankkapurha	Hela-394	x		x		5800	70	-26,10	5800	70	ccr	pottery (Spr 1)	Schulz 2004	KM 31785:1275
Spr 1	FIN	Saarijärvi	Rusavierto	Su-2717			x		5800	40	-25,20	5800	40	coal	cultural layer	Leskinen 2002	
Spr 1	RUS		Panozero 1	KIA-33924	x		x		5795	35	-26,49	5795	35	bbt	pottery (Spr 1)	Piezonka 2008	
Spr 1	FIN	Simo	Tainiaro	Hel-2108			x		5790	100		5790	100	coal	stone structure	Junno et al. 2015	
Spr 1	FIN	Loimaa	Kojonperä	Hel-2376	x		x		5790	140	-25,00	**5756**	**141**	ccr	pottery (Spr 1)	Luoto & Terho 1988	
Spr 1	FIN	Lappeenranta	Etu- ja Taka-Muntero	Hela-2296		x	x		5783	39	-27,50	5783	39	bone	mammal bone	Paper III	KM 37988:211

Spr 1	FIN	Simo	Tainiaro	GrA-63483			x		5775	40	-27,79	5775	40	ccr	pottery (Spr 1)	Nordqvist & Mökkönen 2016a	KM 22398:920
Spr 1	FIN	Taipalsaari	Vaateranta	Ua-3326		x			5775	100		5775	100	coal	burial	Räty 1995	
Spr 1	FIN	Simo	Tainiaro	Hel-2107			x		5770	110		5770	110	coal	burial	Junno et al. 2015	
Spr 1	FIN	Oulu	Pahkakoski 1	Hela-96	x		x		5770	80	-28,40	5770	80	ccr	pottery (Spr 1)	Hallgren 2004	KM 14894:221
Spr 1	FIN	Simo	Tainiaro	Hel-2978			x		5760	120	-25,50	5760	120	coal	burial	Junno et al. 2015	
Spr 1	FIN	Oulu	Pahkakoski 1	Hela-99	x		x		5745	130	-26,20	5745	130	ccr	pottery (Spr 1)	Hallgren 2004	KM 14894:352+245
Spr 1	RUS		Orovnavolok V	TA-2266			x		5720	60		5720	60	coal	fireplace	Timofeev et al. 2004	
Spr 1	FIN	Kouvola	Ankkapurha	Hela-445	x		x		5650	80	-25,20	**5623**	**81**	ccr	pottery (Spr 1)	Schulz 2004	KM 32191:2250
Spr 1	RUS	Viipuri	Selänkangas	GrA-63525			x		5639	40	-24,96	**5603**	**44**	ccr	pottery (Spr 1)	Nordqvist & Mökkönen 2016a	KM 6114:275
Spr 1	FIN	Oulu	Pahkakoski 1	Hela-98	x		x		5615	95	-27,90	5615	95	ccr	pottery (Spr 1)	Hallgren 2004	KM 14894:310
Spr 1	FIN	Kouvola	Ankkapurha	Hela-443	x		x		5595	90	-27,10	5595	90	ccr	pottery (Spr 1)	Schulz 2004	KM 32191:633
Spr 1	FIN	Saarijärvi	Uimaranta	Hela-546	x		x		5590	75	-27,40	5590	75	bbt	pottery (Spr 1)	Paper II	KM 32862:593
Spr 1	FIN	Saarijärvi	Rusavierto	Hela-2208			x		5577	38	-18,70	5577	38	bone	seal bone	Leskinen 2002	KM 32195:8084
Spr 1	FIN	Polvijärvi	Multavieru	Hel-3911			x		5550	120	-25,20	5550	120	coal	fireplace	Junno et al. 2015	
Spr 1	FIN	Kokemäki	Kraviojankangas	Hel-1382			x		5540	100		5540	100	coal	cultural layer?	Nuñez 1990	
Spr 1	RUS		Vozmaricha 26	KIA-35901	x		x		5505	50	-27,63	5505	50	ccr	pottery (Spr 1)	Piezonka 2008	
Spr 1	RUS		Erpin Pudas 1	TA-800			x		5460	80		5460	80	coal	fireplace	Timofeev et al. 2004	
Spr 1	FIN	Raasepori	Timmerkärr	Hela-3175			x		5451	44	-27,50	5451	44	ccr	pottery (Spr 1)	Paper IV	KM 31106:185
Spr 1	FIN	Simo	Tainiaro	Hel-2979			x		5430	120	-23,50	5430	120	coal	burial	Junno et al. 2015	
Spr 1	FIN	Simo	Tainiaro	Hel-2977			x		5410	120	-26,10	5410	120	coal	burial	Junno et al. 2015	
Spr 1	FIN	Oulu	Latokangas	Hel-3059			x		5410	110	-24,80	5410	110	coal	fireplace	Junno et al. 2015	
Spr 1	FIN	Kokemäki	Kraviojankangas	Hel-1381			x		5300	110		5300	110	coal	cultural layer?	Nuñez 1990	
Spr 1	FIN	Porvoo	Henttala	Hela-2666			x		5263	36	-26,60	5263	36	coal	fireplace	Paper IV	
Spr 1	FIN	Lieksa	Haasiinniemi	Hel-3574			x		5240	110	-25,40	5240	110	coal	fireplace	Katiskoski 1996	
Spr 2	FIN	Pielavesi	Kivimäki	GrA-62077			x		5680	40	-29,20	5680	40	ccr	pottery (Spr 2)	Nordqvist & Mökkönen 2016a	KM 24465:17d
Spr 2	FIN	Pielavesi	Kivimäki	GrA-62176			x		5675	40	-27,04	5675	40	ccr	pottery (Spr 2)	Nordqvist & Mökkönen 2016a	KM 24465:206
Spr 2	FIN	Pielavesi	Kivimäki	Hela-2873			x		5661	43	-28,40	5661	43	ccr	pottery (Spr 2)	Paper IV	KM 24465:17D
Spr 2	FIN	Pielavesi	Kivimäki	Hel-2726			x		5660	120	-25,90	5660	120	coal	fireplace	Junno et al. 2015	

Spr 2	RUS	Pyhäjärvi	Kunnianniemi	Hela-1817			x		5635	45	-30,20	5635	45	ccr	pottery (Spr 2)	Seitsonen et al. 2009	
Spr 2	FIN	Simo	Tainiaro	GrA-63478			x		5615	40	-25,56	**5600**	**41**	ccr	pottery (Spr 2)	Nordqvist & Mökkönen 2016a	KM 22398:5a
Spr 2	FIN	Raasepori	Timmerkärr	Hela-3170			x		5614	41	-25,90	**5611**	**41**	ccr	pottery (Spr 2)	Paper IV	KM 31635:210
Spr 2	FIN	Lappeenranta	Saksanniemi	Hela-2952		x	x		5599	42	-28,40	5599	42	ccr	pottery (Spr 2)	Paper III	KM 12169:63
Spr 2	FIN	Kouvola	Ankkapurha	Hela-446	x		x		5590	70	-23,90	**5518**	**78**	ccr	pottery (Spr 2)	Schulz 2004	KM 32191:1838
Spr 2	RUS	Viipuri	Selänkangas	GrA-63527			x		5550	40	-26,56	5550	40	ccr	pottery (Spr 2)	Nordqvist & Mökkönen 2016a	KM 6253:214
Spr 2	FIN	Kouvola	Ankkapurha	Hela-392	x		x		5510	60	-26,60	5510	60	ccr	pottery (Spr 2)	Schulz 2004	KM 31785:491
Spr 2	RUS	Viipuri	Selänkangas	GrA-63526			x		5490	40	-28,32	5490	40	ccr	pottery (Spr 2)	Nordqvist & Mökkönen 2016a	KM 6114:275
Spr 2	FIN	Kurikka	Järvimäki	Hela-3171			x		5477	41	-29,70	5477	41	ccr	pottery (Spr 2)	Paper IV	KM 27463:1
Spr 2	FIN	Espoo	Kläppkärr	Hela-3173			x		5439	43	-26,00	5439	43	ccr	pottery (Spr 2)	Paper IV	KM 31107:399
Spr 2	FIN	Vantaa	Storskogen	Ua-32193	x		x		5415	45	-25,70	**5405**	**45**	ccr	pottery (Spr 2)	Leskinen & Pesonen 2008	KM 9665: 57
Spr 2	FIN	Kouvola	Ankkapurha	Hela-444	x		x		5410	75	-26,00	5410	75	ccr	pottery (Spr 2)	Schulz 2004	KM 32191:684
Spr 2	RUS	Viipuri	Selänkangas	GrA-63524			x		5365	40	-27,50	5365	40	ccr	pottery (Spr 2)	Nordqvist & Mökkönen 2016a	KM 6114:198
Spr 2	FIN	Kouvola	Ankkapurha	Hela-393	x		x		5360	70	-23,80	**5284**	**79**	ccr	pottery (Spr 2)	Schulz 2004	KM 31785:1260
Spr 2	FIN	Kurikka	Mylläri 2	Hel-2112			x		5340	110		5340	110	coal	fireplace	Junno et al. 2015	
Spr 2	FIN	Saarijärvi	Uimaranta	Hela-642	x		x		5335	45	-29,40	5335	45	ccr	pottery (Spr 2)	Paper II	KM 33321:4189
Spr 2	FIN	Saarijärvi	Uimaranta	Hel-4572			x		5310	70	-24,20	5310	70	coal	fireplace	Paper IV	
Spr 2	FIN	Saarijärvi	Uimaranta	Hel-4573			x		5300	120	-26,00	5300	120	coal	fireplace	Paper IV	
Spr 2	FIN	Saarijärvi	Rusavierto	Hel-4517			x		5240	80	-26,10	5240	80	coal	fireplace	Leskinen 2002	
Spr 2	FIN	Kurikka	Mylläri 2	Hel-2113			x		5210	140		5210	140	coal	cultural layer	Junno et al. 2015	
Spr 2	FIN	Pielavesi	Kivimäki	Hel-2725			x		5040	150	-25,50	5040	150	coal	cultural layer?	Junno et al. 2015	
Spr 2	FIN	Hamina	Tonttila	Hel-2293			x		4890	110	-25,30	4890	110	coal	cultural layer?	Junno et al. 2015	
Sär 1	NOR	Nesseby	Nordli	Tua-3028	x				6570	60	-22,8	**6394**	**95**	ccr	pottery (Sär 1)	Skandfer 2005; 2009	
Sär 1	RUS		Kalmozero 11	KIA-35899#	x				6340	70		6340	70	ccr	pottery (Sär 1)	Piezonka 2008	
Sär 1	NOR	Nesseby	Nordli	Tua-3021	x				6330	50	-22,8	**6154**	**89**	ccr	pottery (Sär 1)	Skandfer 2005; 2009	
Sär 1	NOR	Sör-Varanger	Noatun Innmarken	Tua-3023	x				6185	65	-22,9	**6014**	**98**	ccr	pottery (Sär 1)	Skandfer 2005; 2009	
Sär 1	FIN	Utajärvi	Pyhänniska	Hela-148	x				6140	105	-27,5	6140	105	ccr	pottery (Sär 1)	Torvinen 2000	

Sär 1	FIN	Oulu	Vepsänkangas	Hela-236	x				6120	75	-26,3	6120	75	ccr	pottery (Sär 1)	Torvinen 2000	
Sär 1	RUS		Kalmozero 11	KIA-35899#	x				6080	45		6080	45	ccr	pottery (Sär 1)	Piezonka 2008	
Sär 1	NOR	Nesseby	Lossoas hus	Tua-3024	x				6065	55	-23,8	**5944**	**85**	ccr	pottery (Sär 1)	Skandfer 2005; 2009	
Sär 1	NOR	Sör-Varanger	Inganeset	Tua-3025	x				6065	55	-24,3	**5972**	**81**	ccr	pottery (Sär 1)	Skandfer 2005; 2009	
Sär 1	NOR	Sör-Varanger	Noatun Neset Vest	Tua-3026	x				6030	70	-23	**5865**	**100**	ccr	pottery (Sär 1)	Skandfer 2005; 2009	
Sär 1	FIN	Oulu	Vepsänkangas	Hela-128	x				5995	65	-22,2	**5864**	**91**	ccr	pottery (Sär 1)	Torvinen 2000	
Sär 1	FIN	Oulu	Vepsänkangas	Hela-312	x				5990	60	-27,3	5990	60	bbt	pottery (Sär 1)	Koivisto 1998	
Sär 1	NOR	Sör-Varanger	Mennikka	Tua-3027	x				5975	60	-24,4	**5887**	**84**	ccr	pottery (Sär 1)	Skandfer 2005; 2009	
Sär 1	NOR	Sör-Varanger	Noatun Neset	Beta-13126	x				5950	90		5950	90	ccr	pottery (Sär 1)	Skandfer 2005; 2009	
Sär 1	NOR	Sör-Varanger	Noatun Innmarken	Tua-3929	x				5850	55	-21,2	**5585**	**106**	ccr	pottery (Sär 1)	Skandfer 2005; 2009	
Sär 1	FIN	Inari	Rönkönraivio	Hela-38	x				5830	85	-28,2	5830	85	ccr	pottery (Sär 1)	Torvinen 2000	
Sär 1	FIN	Kemijärvi	Neitilä 4	Hela-34	x				5800	90	-25,1	**5769**	**91**	ccr	pottery (Sär 1)	Torvinen 2000	
Sär 1	FIN	Oulu	Latokangas	Hela-146	x				5795	90	-27	5795	90	ccr	pottery (Sär 1)	Torvinen 2000	
Sär 1	NOR	Sör-Varanger	Mennikka	Tua-3022	x				5795	55	-22,1	**5580**	**98**	ccr	pottery (Sär 1)	Skandfer 2005; 2009	
Sär 1	FIN	Oulu	Latokangas	Hela-42	x				5790	105	-25,7	**5780**	**105**	ccr	pottery (Sär 1)	Torvinen 2000	
Sär 1	FIN	Rovaniemi	Ylitalo/Toivola	Hela-40	x				5520	185	-20,3	**5324**	**208**	ccr	pottery (Sär 1)	Torvinen 2000	
Sär 1	FIN	Rovaniemi	Jokkavaara	Hela-57	x				5070	80	-25,9	**5067**	**80**	ccr	pottery (Sär 1)	Torvinen 2000	
TCW	FIN	Hankasalmi	Autioniemi	Hel-30			x		5500	170		5500	170	coal	fireplace	Meinander 1971	KM 14863:20
TCW	FIN	Ruotsinpyhtää	Holmgård	Hel-19			x		5450	150		5450	150	coal	fireplace	Meinander 1971	KM 13957:21
TCW	FIN	Jyväskylä	Lähdemäki	Hel-1218			x		5340	100		5340	100	coal	fireplace	Matiskainen 1979	
TCW	FIN	Ruotsinpyhtää	Holmgård	Hel-11			x		5250	150		5250	150	coal	fireplace	Meinander 1971	KM 13957:8
TCW	FIN	Suonenjoki	Saunaniemi	Hel-28			x		5200	150		5200	150	coal	fireplace	Meinander 1971	KM 14821:1
TCW	FIN	Oulu	Kierikin sorakuoppa	Hel-2472			x		5180	140	-25,00	5180	140	coal	cultural layer	Mökkönen & Nordqvist 2018	
TCW	FIN	Tervola	Törmävaara	Hela-78			x		5160	100	-25,60	**5146**	**100**	ccr	pottery (TCW)	Pesonen 2004	KM 21599:453
TCW	FIN	Eura	Kolmhaara	Hela-362			x		5155	60	-22,50	**5035**	**84**	ccr	pottery (TCW)	Pesonen 2004	KM 15218:197
TCW	FIN	Pieksämäki	Vemmellahti	Hel-2184			x		5150	100		5150	100	coal	fireplace	Junno et al. 2015	
TCW	FIN	Oulu	Kierikin sorakuoppa	Hel-2466			x		5130	130	-25,40	5130	130	coal	cultural layer	Mökkönen & Nordqvist 2018	

TCW	FIN	Kaustinen	Kangas	Hela-161			x		5115	85	-22,50	5115	85	coal	burial	Halinen 1997	
TCW	FIN	Vantaa	Maarinkunnas	Hela-238			x		5110	75	-26,90	5110	75	coal	fireplace	Leskinen & Pesonen 2008	
TCW	FIN	Kuusankoski	Kymenranta	Hel-1095			x		5100	130		5100	130	wood	sledge runner	Kuokkanen 2000	KM 20117
TCW	FIN	Kaustinen	Kangas	Hel-4000			x		5090	100	-24,70	5090	100	coal	fireplace	Halinen 1997	
TCW	FIN	Oulu	Kierikinkangas	Hela-409			x		5085	125	-27,20	5085	125	bbt	pottery (TCW)	Pesonen 2004	KM 31829:295
TCW	FIN	Mynämäki	Aisti	Hela-3077			x		5071	42	-24,10	**5006**	**53**	ccr	pottery (TCW)	Paper IV	KM 16429:15
TCW	FIN	Oulu	Kotikangas NE	Beta-217712			x		5070	50		5070	50	coal	cultural layer?	Costopoulos et al. 2012	
TCW	FIN	Eura	Tyttöpuisto	Hel-1805			x		5070	100		5070	100	coal	fireplace	Junno et al. 2015	
TCW	FIN	Rääkkylä	Vihi 1	Poz-5978		x	x		5070	40		5070	40	bbt	pottery (TCW)	Varonen 2007	KM 30460: 806
TCW	FIN	Joroinen	Kanava	Hela-848		x	x		5065	55	-27,60	5065	55	ccr	pottery (TCW)	Schulz 2006	
TCW	FIN	Laukaa	Hartikka	Hel-2716		x	x		5060	120	-22,30	5060	120	coal	fireplace	Junno et al. 2015	KM 23697:139
TCW	FIN	Eura	Tyttöpuisto	Hel-1803			x		5060	100		5060	100	coal	fireplace	Junno et al. 2015	
TCW	FIN	Lieto	Kukkarkoski I	Hela-118			x		5060	65	-28,50	5060	65	bbt	pottery (TCW)	Pesonen 1999a	KM 19727:89
TCW	FIN	Rääkkylä	Vihi 1	Hela-250		x	x		5055	75	-28,30	5055	75	bbt	pottery (TCW)	Pesonen 1999a	KM 30460:2921
TCW	FIN	Oulu	Kierikin sorakuoppa	Hel-2474			x		5050	130	-24,90	5050	130	coal	cultural layer	Mökkönen & Nordqvist 2018	
TCW	FIN	Eura	Tyttöpuisto	Hel-2722			x		5050	110	-25,70	5050	110	coal	fireplace	Junno et al. 2015	KM 24540:251
TCW	FIN	Pieksämäki	Naarajärvi	Hel-1785		x	x		5050	110		5050	110	coal	fireplace	Matiskainen & Jussila 1984	KM 21519:634
TCW	FIN	Saarijärvi	Voudinniemi	Su-2497		x	x		5050	40	-25,70	5050	40	coal	waste pit	Paper IV	
TCW	FIN	Taipalsaari	Vaateranta	Hela-739		x	x		5045	45	-21,90	5045	45	bone	human bone	Katiskoski 2004	KM 19239:677c
TCW	FIN	Rääkkylä	Vihi 1	Poz-5979		x	x		5045	45		5045	45	bbt	pottery (TCW)	Varonen 2008	KM 30460: 2577
TCW	FIN	Vantaa	Jokiniemi	Hel-3634			x		5040	80	-25,30	5040	80	coal	fireplace	Leskinen & Pesonen 2008	KM 28065:10346
TCW	FIN	Oulu	Kotikangas NE	Beta-217716			x		5040	50		5040	50	coal	cultural layer?	Costopoulos et al. 2012	
TCW	FIN	Vantaa	Maarinkunnas	Hela-356			x		5040	60	-23,20	**4944**	**76**	ccr	pottery (TCW)	Leskinen 2003	KM 30464:7520
TCW	FIN	Taipalsaari	Vaateranta	Hela-117		x	x		5035	70	-27,00	5035	70	bbt	pottery (TCW)	Pesonen 1999a	KM 19239:651
TCW	FIN	Porvoo	Henttala	Hela-2665			x		5024	36	-25,10	5024	36	coal	cultural layer?	Paper IV	
TCW	FIN	Vantaa	Stenkulla	Hel-3961			x		5020	110	-25,20	5020	110	coal	fireplace	Leskinen & Pesonen 2008	
TCW	FIN	Eura	Tyttöpuisto	Hel-1802			x		5020	100		5020	100	coal	fireplace	Junno et al. 2015	
TCW	FIN	Kaustinen	Kangas	Hela-172			x		5020	65	-26,20	5020	65	ccr	pottery (TCW)	Halinen 1997	

TCW	FIN	Rovaniemi	Piirittävaara	Hela-122			x		5015	60	-27,60	5015	60	bbt	pottery (TCW)	Pesonen 1999	KM 25334:210
TCW	FIN	Oulu	Kierikinkangas	Hela-310			x		5010	65	-26,60	5010	65	coal	cultural layer	Mökkönen & Nordqvist 2018	
TCW	FIN	Taipalsaari	Vaateranta	Hela-317		x	x		5010	75	-25,50	5010	75	bbt	chewing resin	Katiskoski 2004	
TCW	FIN	Kitee	Sarvisuo	Hela-152		x	x		5005	70	-27,90	5005	70	bbt	pottery (TCW)	Pesonen 1999	KM 29714:125
TCW	FIN	Tervola	Törmävaara	Hel-2153			x		5000	110		5000	110	coal	fireplace	Junno et al. 2015	
TCW	FIN	Kotka	Pykinkoski	Hel-2305			x		5000	140	-24,10	5000	140	coal	cultural layer	Junno et al. 2015	KM 22899:809
TCW	FIN	Kinnula	Häähkäniemi	Hel-3056		x	x		5000	120	-24,40	5000	120	coal	fireplace	Junno et al. 2015	
TCW	FIN	Vantaa	Stenkulla	Hel-3962			x		5000	120	-24,90	5000	120	coal	fireplace	Leskinen & Pesonen 2008	
TCW	FIN	Pihtipudas	Madeneva	Hela-322		x	x		4995	95	-29,40	4995	95	ccr	pottery (TCW)	Miettinen 2002	KM 30978:153-156
TCW	FIN	Joroinen	Kanava	Hela-703		x	x		4995	45	-28,50	4995	45	bbt	pottery (TCW)	Schulz 2006	
TCW	FIN	Laukaa	Hartikka	Hel-2715		x	x		4990	110	-24,80	4990	110	coal	fireplace	Junno et al. 2015	KM 23697:138
TCW	FIN	Oulu	Kuuselankangas	GrA-63491			x		4990	35	-25,91	4990	35	bbt	chewing resin	Mökkönen & Nordqvist 2018	
TCW	FIN	Outokumpu	Sätös	Hela-116		x	x		4990	70	-27,40	4990	70	bbt	pottery (TCW)	Pesonen 1999	KM 18225:308
TCW	FIN	Outokumpu	Lintutorni	Hela-224		x	x		4990	60	-27,00	4990	60	bbt	pottery (TCW)	Karjalainen 2002	KM 30319:1403
TCW	FIN	Outokumpu	Lintutorni	Hela-227		x	x		4985	75	-25,70	4985	75	bbt	pottery (TCW)	Karjalainen 2002	KM 30319:832
TCW	FIN	Vantaa	Stenkulla	Hel-3965			x		4980	100	-25,60	4980	100	coal	fireplace	Leskinen & Pesonen 2008	
TCW	FIN	Rääkkylä	Vihi 1	Hela-765		x	x		4980	65	-29,10	4980	65	ccr	pottery (TCW)	Paper II	KM 30460:1925
TCW	FIN	Rääkkylä	Vihi 1	Poz-5980		x	x		4980	80		4980	80	bbt	pottery (TCW)	Varonen 2007	KM 30460: 3264
TCW	FIN	Rääkkylä	Pörrinmökki	Hela-123		x	x		4975	60	-26,60	4975	60	bbt	pottery (TCW)	Pesonen 1999	KM 28013:9374
TCW	FIN	Taipalsaari	Vaateranta	Hela-2209			x		4973	37	-28,00	4973	37	bone	seal bone	Katiskoski 2004	KM 30322:919
TCW	FIN	Suonenjoki	Saunaniemi	Hel-29		x	x		4970	150		4970	150	coal	fireplace	Meinander 1971	KM 14821:82
TCW	FIN	Kerimäki	Kankaanlaita	Hel-3060		x	x		4970	110	-24,10	4970	110	coal	ceramic concentration	Moisanen 1991	
TCW	FIN	Vantaa	Stenkulla	Hel-3963			x		4970	90	-25,00	4970	90	coal	fireplace	Leskinen & Pesonen 2008	
TCW	FIN	Pieksämäki	Naarajärvi	Hel-1786		x	x		4970	110		4970	110	coal	fireplace	Matiskainen & Jussila 1984	KM 21519:634
TCW	FIN	Outokumpu	Lintutorni	Hela-223		x	x		4970	60	-29,40	4970	60	bbt	pottery (TCW)	Karjalainen 2002	KM 30319:746
TCW	FIN	Taipalsaari	Kujansuu	Hela-410		x	x		4970	80	-27,60	4970	80	bbt	pottery (TCW)	Pesonen 2004	KM 31825:231
TCW	RUS	Muolaa	Telkkälä	Hela-553		x	x		4965	80	-27,00	4965	80	ccr	pottery (TCW)	Takala & Sirviö 2003	

TCW	RUS	Muolaa	Telkkälä	Hela-591		x	x		4965	60	-26,00	4965	60	coal	fireplace	Takala & Sirviö 2003	
TCW	FIN	Joroinen	Kanava	Hela-849		x	x		4960	55	-26,80	4960	55	bbt	chewing resin	Schulz 2006	
TCW	FIN	Kotka	Niskasuo	Hela-1649			x		4950	35	-23,60	**4868**	**53**	ccr	pottery (TCW)	Paper IV	
TCW	FIN	Outokumpu	Lintutorni	Hela-226		x	x		4950	60	-27,60	4950	60	bbt	pottery (TCW)	Karjalainen 2002	KM 30319:756
TCW	FIN	Tervola	Törmävaara	Hela-107			x		4945	70	-23,70	**4866**	**80**	ccr	pottery (TCW)	Pesonen 2004	KM 22481:2236
TCW	FIN	Liperi	Jyrinlahti 1-4	Hela-364		x	x		4945	70	-27,10	4945	70	bbt	pottery (TCW)	Pesonen 2004	KM 29548:1
TCW	FIN	Liperi	Kyläsärkkä	Hela-2566		x	x		4941	44	-28,50	4941	44	bone	reindeer/elk bone	Paper III	KM 23111:45
TCW	FIN	Eura	Tyttöpuisto	Hel-1801			x		4940	100		4940	100	coal	fireplace	Junno et al. 2015	
TCW	FIN	Loviisa	Kvarnbacken	Hel-310			x		4940	130		4940	130	coal	fireplace	Junno et al. 2015	
TCW	FIN	Tervola	Törmävaara	Hela-105			x		4940	75	-24,00	**4871**	**82**	ccr	pottery (TCW)	Pesonen 2004	KM 22070:1067
TCW	FIN	Vantaa	Maarinkunnas	Hela-357			x		4940	60	-22,50	**4820**	**84**	ccr	pottery (TCW)	Leskinen 2003	KM 30464:11228
TCW	FIN	Jyväskylä	Peuha	Hel-2306		x	x		4930	100	-24,00	4930	100	coal	fireplace	Junno et al. 2015	
TCW	FIN	Eura	Tyttöpuisto	Hel-1804			x		4930	100		4930	100	coal	fireplace	Junno et al. 2015	
TCW	RUS	Pyhäjärvi	Kunnianniemi	Hela-1816		x	x		4930	35	-25,40	**4910**	**36**	ccr	pottery (TCW)	Seitsonen et al. 2009	
TCW	FIN	Rääkkylä	Vihi 1	Poz-6195		x	x		4930	35		4930	35	bbt	pottery (TCW)	Varonen 2007	KM 30460: 3264
TCW	FIN	Pieksämäki	Naarajärvi	Hel-1787		x	x		4920	110		4920	110	coal	fireplace	Matiskainen & Jussila 1984	KM 21519:634
TCW	FIN	Pieksämäki	Naarajärvi	Hela-119		x	x		4920	60	-28,40	4920	60	bbt	pottery (TCW)	Pesonen 1999a	KM 21519:412
TCW	FIN	Vantaa	Sandåker	Ua-32198			x		4920	45	-19,90	**4710**	**112**	ccr	pottery (TCW)	Leskinen & Pesonen 2008	KM 26173: 1508
TCW	FIN	Rääkkylä	Pörrinmökki	Hela-150		x	x		4915	65	-28,30	4915	65	bbt	pottery (TCW)	Pesonen 1999a	KM 29713:289
TCW	FIN	Kaustinen	Kangas	Hel-3999			x		4910	100	-26,20	4910	100	coal	fireplace	Halinen 1997	
TCW	FIN	Oulu	Kierikinkangas	Hel-4405			x		4910	110	-24,30	4910	110	coal	cultural layer	Mökkönen & Nordqvist 2018	
TCW	FIN	Noormarkku		Hel-1096			x		4910	150		4910	150	wood	sledge runner	Aalto et al. 1981	
TCW	FIN	Jyväskylä	Peuha	Hela-121		x	x		4910	60	-28,50	4910	60	bbt	pottery (TCW)	Pesonen 1999	KM 22900:260
TCW	RUS	Räisälä	Peltola C	Hela-1159		x	x		4905	45	-27,40	4905	45	bone		Halinen & Mökkönen 2009	
TCW	FIN	Taipalsaari	Kujansuu	Hela-411		x	x		4905	65	-27,90	4905	65	bbt	pottery (TCW)	Pesonen 2004	KM 31825:664
TCW	FIN	Rovaniemi	Piirittävaara	Hel-3032			x		4900	120	-24,90	4900	120	coal	fireplace	Junno et al. 2015	
TCW	FIN	Taipalsaari	Vaateranta	Hela-315		x	x		4895	70	-28,40	4895	70	bbt	chewing resin	Katiskoski 2004	

TCW	FIN	Oulu	Kierikin sorakuoppa	Hel-2475			x		4890	120	-26,00	4890	120	coal	cultural layer	Mökkönen & Nordqvist 2018	
TCW	FIN	Rovaniemi	Piirittävaara	Hel-2927			x		4890	110	-23,70	4890	110	coal	fireplace	Junno et al. 2015	
TCW	FIN	Joroinen	Kanava	Hela-897		x	x		4890	60	-26,40	4890	60	bone	fish bones	Schulz 2006	KM 33923:9631
TCW	FIN	Mikkeli	Neulaportti	Hela-120		x	x		4885	60	-27,00	4885	60	bbt	pottery (TCW)	Pesonen 1999a	KM 22117:32
TCW	FIN	Vantaa	Jokiniemi	Hela-32			x		4885	60	-25,30	4885	60	nut		Leskinen & Pesonen 2008	KM 28382:2828
TCW	FIN	Pielavesi	Meijerinkangas	Hel-3058			x		4880	100	-24,40	4880	100	coal	fireplace	Paper IV	KM 26088:82
TCW	FIN	Rääkkylä	Pörrinmökki	Hel-3966		x	x		4880	100	-24,40	4880	100	coal	fireplace	Pesonen 1999a	
TCW	FIN	Kangasala	Sarsa	Hel-4402		x	x		4880	90	-25,40	4880	90	coal	fireplace	Paper III	
TCW	FIN	Saarijärvi	Uimaranta	Hel-4606		x	x		4880	90	-24,80	4880	90	coal		Paper III	KM 33321:4270
TCW	FIN	Lieto	Kukkarkoski	Hel-832			x		4880	150		4880	150	coal	burial	Torvinen 1979	KM 19727:167
TCW	FIN	Rääkkylä	Pörrinmökki	Hela-151		x	x		4880	65	-27,60	4880	65	bbt	chewing resin	Pesonen 1999a	
TCW	FIN	Vantaa	Maarinkunnas	Hela-256			x		4880	60	-21,40	**4722**	**98**	ccr	pottery (TCW)	Leskinen 2003	KM 30464:12889
TCW	FIN	Savonlinna	Pääskylahti	Hela-112		x	x		4875	70	-28,00	4875	70	bbt	pottery (TCW)	Pesonen 1999a	KM 8787:108
TCW	FIN	Kangasala	Sarsa	Hela-363		x	x		4875	70	-27,10	4875	70	bbt	pottery (TCW)	Pesonen 2004	KM 17340:488
TCW	FIN	Joroinen	Kanava	Hela-926		x	x		4875	50	-27,00	4875	50	bbt	chewing resin	Schulz 2006	
TCW	FIN	Vantaa	Sandåker	Ua-32197			x		4875	45	-21,80	**4730**	**84**	ccr	pottery (TCW)	Leskinen & Pesonen 2008	KM 26173: 702
TCW	FIN	Joroinen	Kanava	Hela-705		x	x		4870	45	-28,20	4870	45	bbt	pottery (TCW)	Schulz 2006	
TCW	FIN	Ruokolahti	Karoniemi	Hela-450		x	x		4860	110	-27,50	4860	110	ccr	pottery (TCW)	Paper IV	
TCW	FIN	Kokkola	Bläckisåsen	Su-1484			x		4860	80	-25,00	4860	80	coal	fireplace	Paper IV	
TCW	FIN	Kotka	Pykinkoski	Hel-2303			x		4850	140	-24,80	4850	140	coal	cultural layer	Junno et al. 2015	KM 22899:807
TCW	FIN	Oulu	Kierikin sorakuoppa	GrA-63488			x		4850	35	-25,54	**4830**	**36**	ccr	pottery (TCW)	Mökkönen & Nordqvist 2018	KM 23728:682
TCW	FIN	Tervola	Törmävaara	Hel-2151			x		4840	110		4840	110	coal	waste pit	Junno et al. 2015	
TCW	FIN	Tervola	Törmävaara	Hela-106			x		4840	140	-26,20	4840	140	ccr	pottery (TCW)	Pesonen 2004	KM 22070:1257
TCW	FIN	Rääkkylä	Vihi 1	Hela-251		x	x		4840	80	-27,20	4840	80	bbt	pottery (TCW)	Pesonen 1999a	KM 30460:5589
TCW	FIN	Joroinen	Kanava	Hela-704		x	x		4840	45	-27,90	4840	45	bbt	pottery (TCW)	Schulz 2006	
TCW	FIN	Oulu	Kuuselankangas	Hela-75			x		4840	110	-27,00	4840	110	bbt	chewing resin	Halinen et al. 1998	
TCW	FIN	Raahe	Kauniinmetsänniitty 1	Hela-1710			x		4835	40	-25,10	4835	40	coal	cultural layer	Pesonen 2013	KM 36937:2917
TCW	FIN	Taipalsaari	Vaateranta	Hela-318		x	x		4835	70	-26,80	4835	70	bbt	chewing resin	Katiskoski 2004	

TCW	FIN	Oulu	Kuuselankangas	Hela-162			x		4830	80	-27,20	4830	80	bbt	chewing resin	Halinen et al. 1998	
TCW	FIN	Raahe	Kauniinmetsänniitty 1	Hela-1709			x		4830	40	-27,60	4830	40	coal	cultural layer	Pesonen 2013	KM 36937:2913
TCW	FIN	Outokumpu	Lintutorni	Hela-225		x	x		4830	60	-28,20	4830	60	bbt	pottery (TCW)	Karjalainen 2002	KM 30319:549
TCW	FIN	Nousiainen	Kukonharja 2	Hela-3178			x		4829	40	-18,20	**4560**	**137**	ccr	pottery (TCW)	Paper IV	KM 38207:21
TCW	FIN	Lapinlahti	Kärkkäinen	Hela-111		x	x		4820	70	-28,30	4820	70	bbt	pottery (TCW)	Pesonen 1999a	KM 8603:7
TCW	FIN	Oulu	Kierikinkangas	Hela-408			x		4820	65	-27,20	4820	65	bbt	pottery (TCW)	Pesonen 2004	KM 31829:440
TCW	FIN	Oulu	Kuuselankangas	Hela-76			x		4820	100	-27,00	4820	100	bbt	chewing resin	Halinen et al. 1998	
TCW	FIN	Tervola	Törmävaara	Hel-2156			x		4810	110		4810	110	coal	fireplace	Junno et al. 2015	
TCW	FIN	Kangasala	Sarsa	Hel-4490		x	x		4810	90	-26,10	4810	90	coal	fireplace	Paper III	
TCW	FIN	Oulu	Kotikangas NE	Beta-217714		x			4810	50		4810	50	coal	cultural layer?	Costopoulos et al. 2012	
TCW	FIN	Pihtipudas	Madeneva	Hela-113			x		4810	70	-27,20	4810	70	bbt	pottery (TCW)	Pesonen 1999a	KM 16422:28
TCW	FIN	Polvijärvi	Rukoushuone	Hela-2567		x	x		4810	46	-27,50	4810	46	bone	mammal, fish bone	Paper III	KM 30454:223
TCW	FIN	Rääkkylä	Pörrinmökki	Hela-2874		x	x		4808	39	-27,60	4808	39	bbt	pottery (TCW)	Paper III	KM 27195:162
TCW	FIN	Raahe	Kauniinmetsänniitty 1	Hela-1708			x		4805	40	-25,50	4805	40	coal	cultural layer	Pesonen 2013	KM 36937:2910
TCW	RUS		Solomanni	Hela-2582			x		4802	39	-27,70	4802	39	bbt	pottery (TCW)	Paper IV	KM 11369:1
TCW	FIN	Oulu	Kierikin sorakuoppa	GrA-63487			x		4790	35	-27,36	4790	35	bbt	pottery (TCW)	Mökkönen & Nordqvist 2018	KM 23432:782
TCW	RUS	Johannes	Tokarevo 1:1	Ki-10298		x	x		4790	210		4790	210	coal		Carpelan et al. 2008	
TCW	FIN	Rääkkylä	Vihi 1	Hela-252		x	x		4785	65	-27,90	4785	65	bbt	pottery (TCW)	Pesonen 1999a	KM 30460:2023
TCW	FIN	Rääkkylä	Vihi 1	Hela-766		x	x		4785	55	-28,30	4785	55	bbt	pottery (TCW)	Paper III	KM 30460:4967
TCW	FIN	Turku	Kärsämäki	Hel-1229			x		4780	90		4780	90	coal	fireplace	Junno et al. 2015	
TCW	FIN	Oulu	Kierikinkangas	Hela-1956			x		4780	40	-26,60	4780	40	coal	burial	Viljanmaa 2009	
TCW	FIN	Eura	Kolmhaara	Hela-651			x		4775	65	-26,10	4775	65	coal	fireplace	Paper IV	
TCW	FIN	Tervola	Törmävaara	Hel-2155			x		4770	110		4770	110	coal	fireplace	Junno et al. 2015	
TCW	FIN	Raahe	Kauniinmetsänniitty 1	Hela-1712			x		4770	40	-29,60	4770	40	bbt	pottery (TCW)	Pesonen 2013	
TCW	FIN	Oulu	Kuuselankangas	Hela-74			x		4770	100	-27,70	4770	100	bbt	chewing resin	Halinen et al. 1998	
TCW	FIN	Vantaa	Maarinkunnas	Hela-255			x		4745	60	-27,30	4745	60	bbt	pottery (TCW)	Leskinen 2003	KM 30464:11862
TCW	FIN	Oulu	Kuuselankangas	Hela-463			x		4745	70	-26,10	4745	70	coal	cultural layer	Pesonen 2002	
TCW	FIN	Kaustinen	Kangas	Hela-173			x		4740	60	-27,40	4740	60	ccr	pottery (TCW)	Halinen 1997	

TCW	FIN	Rääkkylä	Vihi 1	Hela-249		x	x		4740	70	-28,10	4740	70	bbt	pottery (TCW)	Pesonen 1999a	KM 30460:6875
TCW	FIN	Lapua	Pitkämäki	Hela-361			x		4740	70	-27,90	4740	70	bbt	pottery (TCW)	Pesonen 2004	KM 14117:31
TCW	FIN	Rääkkylä	Vihi 1	Poz-5872		x	x		4740	35		4740	35	bbt	pottery (TCW)	Varonen 2007	KM 30460: 6648
TCW	FIN	Leppävirta	Voutilainen	Hela-114		x	x		4730	70	-28,50	4730	70	bbt	pottery (TCW)	Pesonen 1999a	KM 13886:234
TCW	FIN	Raahe	Kauniinmetsänniitty 1	Hela-1713			x		4730	40	-25,40	**4710**	**41**	ccr	pottery (TCW)	Pesonen 2013	
TCW	FIN	Rääkkylä	Vihi 1	Hela-2876		x	x		4725	45	-25,90	**4722**	**45**	ccr	pottery (TCW)	Paper III	KM 30460:11840
TCW	FIN	Kangasala	Sarsa	Hel-4401		x	x		4720	70	-25,20	4720	70	coal	fireplace	Paper III	
TCW	FIN	Kangasala	Sarsa	Hel-4403		x	x		4720	80	-25,60	4720	80	coal	fireplace	Paper III	
TCW	FIN	Oulu	Kierikinkangas	Hela-1957			x		4715	40	-29,80	4715	40	bbt	pottery (TCW)	Viljanmaa 2009	
TCW	FIN	Lappeenranta	Murheistenranta	Ua-51563			x		4714	47	-27,20	4714	47	bone	big mammal bone	Paper IV	KM 38390:117
TCW	FIN	Rääkkylä	Vihi 1	Hela-253		x	x		4710	70	-28,00	4710	70	bbt	pottery (TCW)	Pesonen 1999a	KM 30460:633
TCW	FIN	Eura	Kolmhaara	Hela-650			x		4710	55	-23,70	4710	55	nut		Paper IV	
TCW	FIN	Oulu	Kierikinkangas	Hela-311			x		4705	60	-25,00	4705	60	coal	cultural layer	Mökkönen & Nordqvist 2018	
TCW	FIN	Kotka	Pykinkoski	Hel-2304			x		4700	110	-25,10	4700	110	coal	cultural layer	Junno et al. 2015	KM 22899:808
TCW	FIN	Kotka	Niskasuo	Hela-115			x		4700	75	-26,50	4700	75	bbt	pottery (TCW)	Pesonen 1999a	KM 17075:250
TCW	FIN	Oulu	Kierikinkangas	Hela-1707			x		4700	40	-24,80	4700	40	coal	pithouse	Viljanmaa 2009	
TCW	FIN	Raahe	Kauniinmetsänniitty 1	Hela-1714			x		4690	40	-19,60	4690	40	bone	seal bone	Pesonen 2013	KM 36937:2833
TCW	FIN	Kitee	Karistaja	Hela-2568		x	x		4676	43	-28,60	4676	43	bone	elk bone	Paper III	KM 35489:142
TCW	FIN	Oulu	Kotikangas NE	Beta-217711		x			4670	40		4670	40	coal	cultural layer?	Costopoulos et al. 2012	
TCW	FIN	Kitee	Kumpuniemensuo	Hela-2644		x	x		4661	43	-25,60	4661	43	coal	cultural layer	Paper III	KM 34791:7
TCW	FIN	Lappeenranta	Murheistenranta	Ua-51562			x		4658	34	-28,60	4658	34	bbt	pottery (TCW)	Paper IV	KM 37963:62
TCW	FIN	Oulu	Latokangas	Hel-3023			x		4650	80	-24,10	4650	80	coal	cultural layer?	Mäkivuoti 1991	
TCW	FIN	Tervola	Törmävaara	Hel-2154			x		4640	130		4640	130	coal	fireplace	Junno et al. 2015	
TCW	FIN	Lieksa	Pokronlampi	Hel-3184		x	x		4640	120	-25,90	4640	120	coal	fireplace	Junno et al. 2015	KM 27122:407c
TCW	FIN	Alajärvi		Su-2831			x		4640	40		4640	40	wood	sledge runner	Kuokkanen 2000	KM 16110
TCW	FIN	Sotkamo	Kiikarusniemi	Hel-2096			x		4630	110		4630	110	coal	cultural layer	Nieminen & Ruonavaara 1984	KM22198:570
TCW	FIN	Rovaniemi	Piirittävaara	Hel-3031			x		4630	120	-25,50	4630	120	coal	fireplace	Junno et al. 2015	
TCW	FIN	Outokumpu	Somerhiekka	Hela-2574		x	x		4630	32	-27,30	4630	32	bone	mammal, fish bone	Paper III	KM 33540:3

TCW	FIN	Oulu	Kuuselankangas	Su-2699			x		4620	50		4620	50	coal	cultural layer	Halinen et. al. 1998	
TCW	FIN	Joensuu	Saviniemi	Hela-2559		x	x		4608	36	-26,20	4608	36	bone	mammal bone	Paper III	KM 15339:41
TCW	FIN	Oulu	Kierikinkangas	Hela-3064			x		4580	38	-28,10	4580	38	bbt	chewing resin	Pesonen et al. 2013	KM 37797:433
TCW	FIN	Kitee	Lovonranta 2	Hela-2565		x	x		4551	31	-26,70	4551	31	bone	mammal bone	Paper III	KM 34794:4
TCW	FIN	Oulu	Kotikangas NE	Beta-217715		x			4550	40		4550	40	coal	cultural layer?	Costopoulos et al. 2012	
TCW	FIN	Alajärvi		Su-2832			x		4530	40		4530	40	wood	sledge runner	Kuokkanen 2000	KM 16224: 3
TCW	FIN	Tervola	Törmävaara	Hel-2152			x		4490	130		4490	130	coal	fireplace	Junno et al. 2015	
TCW	FIN	Kullaa	Tuurujärvi	Hel-2525			x		4430	110	-20,40	4430	110	wood	sledge runner	Huurre 1991	KM 23896
TCW	FIN	Outokumpu	Laavussuo	Hel-3975			x		4420	100	-25,90	4420	100	coal	pithouse	Karjalainen 2002	
TCW	FIN	Taipalsaari	Vaateranta	Hela-319			x		4315	80	-27,10	4315	80	bbt	chewing resin	Katiskoski 2004	
TCW	FIN	Pieksämäki	Naarajärvi	Hel-1926			x		4200	190		4200	190	coal	posthole	Matiskainen & Jussila 1984	
UCW	FIN	Puumala	Kärmelahti	Hela-333		x			4615	70	-28,30	4615	70	bbt	chewing resin	Katiskoski 2002	
UCW	FIN	Puumala	Kärmelahti	Hela-335		x			4565	65	-26,90	4565	65	bark	house structure	Katiskoski 2002	
UCW	FIN	Puumala	Kärmelahti	Su-3333		x			4480	50		4480	50	coal		Katiskoski 2002	
UCW	FIN	Puumala	Kärmelahti	Hela-334		x			4465	70	-27,60	4465	70	bbt	chewing resin	Katiskoski 2002	
UCW	FIN	Puumala	Kärmelahti	Su-3321		x			4460	59		4460	59	coal		Katiskoski 2002	
	FIN	Imatra	Linnansuo	Hel-8		x			5200	140		5200	140	wood	under flood sediment	Saarnisto 1970	
	FIN	Imatra	Linnansuo	Hel-3253		x			5200	120		5200	120	wood	under flood sediment	Delusin & Donner 1995	
	FIN	Imatra	Linnansuo	P-1542		x			5183	56		5183	56	wood	under flood sediment	Saarnisto 1970	

Appendix II. Charred crust and birch bark tar radiocarbon dates in Neolithic ceramics in eastern Fennoscandia.

Abbreviations. Cultural context: CW = Corded Ware, EAW = Early Asbestos Ware, TCW = Typical Comb Ware, LCW = Late Comb Ware, UCW = unidentified Comb Ware, Jäk = Jäkärlä Ware, Sär 1 = Säräisniemi 1 Ware, Spr 1 = Sperrings 1 Ware, Spr 2 = Sperrings 2 Ware, PitComb = Pit-Comb Ware, Romb = Rhomb-Pit Ware, Zal = Zalavruga Ware, Orov = Orovnavolok Ware, Voy = Voynavolok Ware, Pöl = Pöljä Ware, Kier = Kierikki Ware, Kiuk = Kiukainen Ware, Pala = Palajguba Ware.. Country: FIN = Finland, NOR = Norway, RUS = Russia. Material: ccr = charred crust, bbt = birch bark tar. Dates in red and with an asterisk are outliers identified in the study. MRE corrected dates are in bold.

Cultural context	Country	Municipality	Site	C14 Age BP	C14 Age error	δ13C	Labcode	MRE corrected BP	MRE corr. Error	Material	Reference	Catalogue number
CW	FIN	Seinäjoki	Isosaari	4229	47	-24,70	Hela-2658	**4184**	**52**	ccr	Pesonen et al. 2019	
CW	FIN	Teuva	Kortesnevankangas	4216	28	-28,00	Hela-3429	4216	28	ccr	Holmqvist et al. 2018	KM 18921
CW	FIN	Porvoo	Böle	4210	29	-26,40	Hela-3426	4210	29	ccr	Holmqvist et al. 2018	KM 22004:6006
CW	FIN	Virolahti	Mattilan VPK	4136	29	-23,50	Hela-3428	**4050**	**51**	ccr	Holmqvist et al. 2018	KM 15329:132
CW	FIN	Espoo	Mäntymäki	3897	29	-28,90	Hela-3425	3897	29	ccr	Holmqvist et al. 2018	KM 16288:16
CW	FIN	Virolahti	Meskäärtty	3820	45	-25,00	Hela-1614	**3786**	**48**	ccr	Mökkönen 2008	
CW	FIN	Vantaa	Jönsas	3790	40	-25,20	Ua-32196	**3763**	**42**	ccr	Leskinen & Pesonen 2008	KM 20087:264
CW	RUS		Gvardeyskoe 1	3630	35	-25,88	GrA-62069	3630	35	ccr	Nordqvist & Mökkönen 2016b	MAE -
EAW	FIN	Lappeenranta	Saksanniemi	5421	38	-27,00	Hela-2871	5421	38	bbt	Oinonen et al. 2014	
EAW	FIN	Kiuruvesi	Hukkala	5273	43	-26,50	Hela-3174	5273	43	ccr	unpublished	KM 18975:5
EAW	FIN	Liperi	Kyläsärkkä	5259	39	-25,10	Hela-2872	5259	39	ccr	Oinonen et al. 2014	
EAW	FIN	Rääkkylä	Lappalaissuo	5206	41	-30,50	Hela-2875	5206	41	bbt	Oinonen et al. 2014	
EAW	FIN	Outokumpu	Sätös	5150	35	-26,6	GrA-62218	5150	35	ccr	Nordqvist & Mökkönen 2016	KM 28153:1445
Jäk*	FIN	Mynämäki	Aisti	7450	49	-27,10	Hela-3075	7450	49	ccr	Pesonen & Oinonen 2019	KM 15133:5
Jäk	FIN	Nousiainen	Kukonharju 2	5230	41	-20,80	Hela-2660	**5051**	**97**	ccr	Pesonen & Oinonen 2019	
Jäk	FIN	Raasepori	Telegrafberget	5211	40	-26,80	Hela-3168	5211	40	ccr	Pesonen & Oinonen 2019	KM 32553:6
Jäk	FIN	Espoo	Mynt	5210	40	-26,20	Hela-3166	5210	40	ccr	Pesonen & Oinonen 2019	KM 14594:392
Jäk	FIN	Turku	Jäkärlä	5195	56		Ua-46150	5195	56	ccr	Pääkkönen et al. 2016	
Jäk	FIN	Nousiainen	Kukonharju 2	5177	37	-19,50	Hela-2661	**4953**	**116**	ccr	Pesonen & Oinonen 2019	

Jäk	FIN	Lieto	Kukkarkoski II	5130	40	-25,00	Hela-3176	**5096**	**43**	ccr	Pesonen & Oinonen 2019	KM 16879:161
Jäk	FIN	Turku	Jäkärlä	5119	42	-26,80	Hela-3169	5119	42	ccr	Pesonen & Oinonen 2019	KM 8063:107
Jäk	FIN	Mynämäki	Aisti	5055	41	-26,10	Hela-3076	5055	41	ccr	Pesonen & Oinonen 2019	KM 16078:6
Jäk	FIN	Lieto	Merola	5002	40	-25,70	Hela-3172	**4992**	**40**	ccr	Pesonen & Oinonen 2019	KM 16879:28
Kier	RUS	Johannes	Väntsi	4870	85	-25,50	Hela-465	4870	85	ccr	Huurre 2003; Mökkönen 2009	KM 9406:188
Kier	FIN	Pyhtää	Långkärrskogen 1	4817	33	-25,00	Hela-2688	**4783**	**37**	ccr	unpublished	
Kier	FIN	Yli-Ii	Kuuselankangas	4800	115	-23,40	Hela-51	**4711**	**123**	ccr	Pesonen 2004	
Kier	FIN	Oulu	Kierikkisaari	4765	35	-23,64	GrA-63502	**4684**	**53**	ccr	Mökkönen & Nordqvist 2018	KM 16554:856
Kier	FIN	Oulu	Kierikkisaari	4705	35	-25,89	GrA-63495	**4701**	**35**	ccr	Mökkönen & Nordqvist 2018	KM 16139:2515
Kier	FIN	Oulu	Kierikkisaari	4705	35	-25,74	GrA-63500	**4696**	**35**	ccr	Mökkönen & Nordqvist 2018	KM 16141:905
Kier	FIN	Oulu	Kierikkisaari	4675	35	-28,34	GrA-63493	4675	35	ccr	Mökkönen & Nordqvist 2018	KM 15241:146
Kier	FIN	Oulu	Kierikkisaari	4675	35	-28,73	GrA-63498	4675	35	ccr	Mökkönen & Nordqvist 2018	KM 16140:1181+1292
Kier	RUS	Kurkijoki	Kuuppala	4655	45	-24,30	Hela-1022	4655	45	ccr	Hallgren 2008	IIMK/St.Petersburg
KIer	FIN	Oulu	Kierikkisaari	4645	35	-26,44	GrA-63499	4645	35	bbt	Mökkönen & Nordqvist 2018	KM 16140:1533
Kier	FIN	Oulu	Kierikkisaari	4540	35	-28,62	GrA-63494	4540	35	ccr	Mökkönen & Nordqvist 2018	KM 16139:1860
Kier	SWE	Valbo	Västra Mårtsbo	4515	70	-25,90	Ua-14836	4515	70	ccr	Hallgren 2008	
Kier	FIN	Oulu	Kierikkisaari	4490	35	-28,61	GrA-63947	4490	35	ccr	Mökkönen & Nordqvist 2018	KM 16140:75
Kier	FIN	Suomussalmi	Kalmosärkkä	4485	100	-29,00	Hela-138	4485	100	ccr	Pesonen 2004	KM 14829:106
Kier	FIN	Lappeenranta	Ahvensaari	4450	60	-28,70	Hela-360	4450	60	ccr	Pesonen 2004	
Kier	FIN	Rovaniemi	Kumpuniemi	4450	105	-29,30	Hela-147	4450	105	ccr	Pesonen 2004	KM 15222:543
Kier	FIN	Yli-Ii	Kuuselankangas	4420	90	-23,20	Hela-52	**4324**	**102**	ccr	Pesonen 2004	
LCW	FIN	Vantaa	Maarinkunnas	4940	70	-22,30	Hela-259	**4812**	**93**	ccr	Leskinen 2003	KM 30464:1249
LCW	FIN	Vantaa	Maarinkunnas	4835	70	-24,10	Hela-257	**4769**	**76**	ccr	Leskinen 2003	KM 30464:9427
LCW	RUS	Kaukola	Kyöstälänharju	4780	70	-27,50	Hela-359	4780	70	bbt	Pesonen 2004	KM 5699:9
LCW	FIN	Nousiainen	Kuuvanvuori	4775	55	-22,80	Hela-979	**4664**	**76**	ccr	Paper IV	KM 35020:83
LCW	FIN	Vantaa	Maarinkunnas	4710	75	-22,90	Hela-258	**4603**	**91**	ccr	Leskinen 2003	KM 30464:13811
LCW	FIN	Vantaa	Maarinkunnas	4680	80	-28,30	Hela-254	4680	80	bbt	Leskinen 2003	KM 30464:10801
LCW	FIN	Helsinki	Kårböle folkskola	4620	65	-25,10	Hela-159	**4589**	**66**	ccr	Lesell 2005	
LCW	FIN	Jomala	Jettböle Bergmanstorp	4560	80	-27,70	Ua-15869	4560	80	ccr	Stenbäck 2003	ÅM 696: 80
LCW	RUS	Viipuri	Häyrynmäki	4550	60	-26,50	Hela-358	4550	60	bbt	Pesonen 2004	KM 5620:CCXLIV
LCW	FIN	Virolahti	Meskäärtty	4535	35	-25,10	Hela-1613	**4504**	**38**	ccr	Mökkönen 2008	
LCW	FIN	Virolahti	Meskäärtty	4520	40	-27,50	Hela-1615	4520	40	ccr	Mökkönen 2008	
LCW	FIN	Kristiinankaupunki	Byåsen	4430	40	-26,10	Hela-1532	4430	40	ccr	Paper IV	KM 36485:149
Orov	RUS		Tunguda XV	4570	35	-29,16	GrA-63583	4570	35	ccr	Nordqvist & Mökkönen 2018	AM 2148/250,867
Orov	RUS		Tunguda XV	4515	35	-26,63	GrA-63582	4515	35	ccr	Nordqvist & Mökkönen 2018	AM 2148/468
Orov	RUS		Tunguda XV	4435	35	-26,12	GrA-63584	4435	35	ccr	Nordqvist & Mökkönen 2018	AM 2148/572

Orov	RUS		Orovnavolok XVI	4390	50		Beta-117961	4390	50	ccr	Nordqvist & Mökkönen 2018	
Orov	RUS		Zalavruga I	4285	35	-24,85	GrA-63557	4285	35	ccr	Nordqvist & Mökkönen 2018	AM 378/392
Orov	RUS		Zalavruga I	4255	40	-24,18	GrA-63558	4255	40	ccr	Nordqvist & Mökkönen 2018	AM 378/392
Pala	RUS		Sheltozero XII	3815	35	-27,9	GrA-63585	3815	35	ccr	Nordqvist & Mökkönen 2018	AM 896/252
Pala	RUS		Sheltozero XII	3725	35	-28,98	GrA-63586	3725	35	ccr	Nordqvist & Mökkönen 2018	AM 896/232
Pala?	FIN	Kuusamo	Somostenperä	4115	75	-23,90	Hela-101	4115	75	ccr	unpublished	KM 16734:9
PitComb	RUS		Besovy Sledki II	5635	40	-24,06	GrA-63681	5635	40	ccr	Nordqvist & Mökkönen 2016b	No 149/512
PitComb	RUS		Besovy Sledki	5550	40	-26,3	GrA-63549	5550	40	ccr	Nordqvist & Mökkönen 2016b	No 366/1, 45
PitComb	RUS		Besovy Sledki II	5410	40	-28,16	GrA-63548	5410	40	ccr	Nordqvist & Mökkönen 2016b	No 149/124
PitComb	RUS		Vorob'i 4	5360	70	-27,18	GrA-68145	5360	70	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	5136	120	-22,94	SPb-1786	5136	120	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	5135	45	-24,9	GrA-67742	5135	45	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	5115	120	-26,68	SPb-1822	5115	120	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	5100	120	-24,05	SPb-1785	5100	120	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	5030	60	-30,6	GrA-68144	5030	60	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	5000	40	-28,09	GrA-67744	5000	40	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	4948	110	-19,98	SPb-1775	4948	110	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	4790	120	-23,08	SPb-1783	4790	120	ccr	Nordqvist & German 2018	
PitComb	RUS		Besovy Sledki II	4785	45	-27,39	GrA-64331	4785	45	ccr	Nordqvist & Mökkönen 2016b	No 149/431
PitComb	RUS		Vorob'i 4	4779	110	-24,58	SPb-1777	4779	110	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	4641	120	-25,58	SPb-1781	4641	120	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	4632	150	-24,5	SPb-1778	4632	150	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	4626	120	-26,23	SPb-1782	4626	120	ccr	Nordqvist & German 2018	
PitComb	RUS		Vorob'i 4	4427	150	-23,67	SPb-1779	4427	150	ccr	Nordqvist & German 2018	
Pöl	FIN	Seinäjoki	Isosaari	4680	42	-23,20	Hela-2657	**4584**	**63**	ccr	unpublished	KM 37962:317
Pöl	FIN	Outokumpu	Sätös	4540	75	-28,50	Hela-347	4540	75	ccr	Karjalainen 2002; Pesonen 2004	KM 30892:1318
Pöl	FIN	Outokumpu	Sätös	4525	35	-29,25	GrA-62073	4525	35	ccr	Nordqvist 2018	KM 28153:4798
Pöl	FIN	Yli-Ii	Purkajasuo	4475	60	-28,80	Hela-136	4475	60	ccr	Pesonen 2004	KM 29764:48
Pöl	FIN	Pieksämäki	Tahiniemi	4470	35	-25,55	GrA-62066	4470	35	ccr	Nordqvist 2018	KM 23445:453
Pöl	FIN	Iisalmi	Jysmä	4465	35	-29,01	GrA-63530	4465	35	ccr	Nordqvist 2018	KM 13944:73
Pöl	FIN	Outokumpu	Sätös	4425	55	-30,00	Hela-349	4425	55	ccr	Karjalainen 2002; Pesonen 2004	KM 30892:240
Pöl	FIN	Outokumpu	Sätös	4415	75	-30,10	Hela-345	4415	75	ccr	Karjalainen 2002; Pesonen 2004	KM 30892:1754
Pöl	FIN	Rantasalmi	Ritokangas	4400	100	-27,5	GrA-62071	4400	100	bbt	Nordqvist 2018	KM 30771:418b
Pöl	FIN	Outokumpu	Sätös	4390	70	-29,50	Hela-346	4390	70	ccr	Karjalainen 2002; Pesonen 2004	KM 30892:1553
Pöl	FIN	Suomussalmi	Kukkosaari	4390	100	-32,60	Hela-145	4390	100	ccr	Pesonen 2004	KM 25423:1
Pöl	FIN	Outokumpu	Sätös	4380	35	-28,96	GrA-62083	4380	35	ccr	Nordqvist 2018	KM 30892:2492

Pöl	FIN	Suomussalmi	Kalmosärkkä	4370	90	-27,20	Hela-139	4370	90	ccr	Pesonen 2004	KM 14829:103,116
Pöl	FIN	Outokumpu	Sätös	4310	50	-24,94	GrA-62486	4310	50	ccr	Nordqvist 2018	KM 30892:1835
Pöl	FIN	Punkaharju	Salkoniemi	4300	60	-27,00	Hela-769	4300	60	ccr	Lesell 2005	KM 34311:54
Pöl	FIN	Outokumpu	Sätös	4290	60	-28,40	Hela-348	4290	60	ccr	Karjalainen 2002; Pesonen 2004	KM 30892:1159
Pöl	FIN	Posio	Kuorikkikangas	4290	80	-28,10	Su-2682	4290	80	ccr	Pesonen 2004; Pesonen 2006	KM 28917:1006
Pöl	FIN	Suomussalmi	Joenniemi	4285	80	-27,70	Hela-100	4285	80	ccr	Pesonen 2004	KM 24506:159
Pöl	FIN	Outokumpu	Laavussuo	4255	35	-28,61	GrA-62067	4255	35	ccr	Nordqvist 2018	KM 29556:481
Pöl	FIN	Rantasalmi	Ritokangas	4250	140	-27,99	GrA-62508	4250	140	ccr	Nordqvist 2018	KM 30771:418a
Pöl	FIN	Kouvola	Pukkisaari	4247	42	-26,90	Hela-2648	4247	42	ccr	unpublished	
Pöl	FIN	Rantasalmi	Pirskanlahti B	4245	35	-34,45	GrA-62215	4245	35	bbt	Nordqvist 2018	KM 32004:2058
Pöl	FIN	Iisalmi	Jysmä	4210	35	-29,19	GrA-63533	4210	35	ccr	Nordqvist 2018	KM 13944:73
Pöl	RUS		Gvardeyskoe	4205	35	-23,55	GrA-62068	4205	35	ccr	Nordqvist & Mökkönen 2018	MAE -
Pöl	FIN	Iisalmi	Jysmä	4175	35	-29,05	GrA-63536	4175	35	ccr	Nordqvist 2018	KM 13944:37
Pöl	FIN	Suomussalmi	Joenniemi	4170	85	-29,50	Hela-143	4170	85	ccr	Pesonen 2004	KM 24506:102, 140
Pöl	FIN	Pieksämäki	Tahiniemi	4125	35	-34,12	GrA-62065	4125	35	ccr	Nordqvist 2018	KM 22955:167
Pöl	FIN	Outokumpu	Laavussuo	4110	50	-28,73	GrA-62485	4110	50	ccr	Nordqvist 2018	KM 29556:1245
Pöl	FIN	Iisalmi	Jysmä	4090	35	-33,35	GrA-63535	4090	35	ccr	Nordqvist 2018	KM 13944:37
Pöl	FIN	Iisalmi	Jysmä	4080	35	-33,64	GrA-63529	4080	35	ccr	Nordqvist 2018	KM 13944:21
Pöl	RUS	Pyhäjärvi	Kunnianniemi	4030	35	-24,90	Hela-1819	**3992**	**40**	ccr	Seitsonen et al. 2012	
Pöl	FIN	Suomussalmi	Joenniemi	4555	80	-29,80	Hela-102	4555	80	ccr	Pesonen 2004	KM 23701:488
Romb	RUS		Orovnavolok XVI	4970	50		Beta-117964	4970	50	ccr	Nordqvist & Mökkönen 2016b	
Romb	RUS		Vygainavolok I	4940	30		KIA-33930	4940	30	ccr	Nordqvist & Mökkönen 2016b	
Romb	RUS		Orovnavolok XVI	4870	50		Beta-117962	4870	50	ccr	Nordqvist & Mökkönen 2016b	
Romb	RUS		Orovnavolok XVI	4840	50		Beta-117963	4840	50	ccr	Nordqvist & Mökkönen 2016b	
Romb	RUS		Pegrema I	4825	35	-27,21	GrA-63684	4825	35	bbt	Nordqvist & Mökkönen 2016b	AM 784/1074
Romb	RUS		Orovnavolok XVI	4770	40		Beta-117966	4770	40	ccr	Nordqvist & Mökkönen 2016b	
Romb	RUS		Pegrema I	4730	35	-28,91	GrA-63686	4730	35	bbt	Nordqvist & Mökkönen 2016b	AM 784/855
Romb	RUS		Vygainavolok I	4725	30		KIA-33931	4725	30	ccr	Nordqvist & Mökkönen 2016b	
Romb	RUS		Pegrema I	4720	35	-27	GrA-63733	4720	35	bbt	Nordqvist & Mökkönen 2016b	AM 721/1090
Romb	RUS		Pegrema I	4695	35	-27,75	GrA-63734	4695	35	ccr	Nordqvist & Mökkönen 2016b	AM 784/1682 +
Spr 1	RUS		Uya III	6225	40	-28,26	GrA-63566	6225	40	ccr	Nordqvist & Mökkönen 2016a	
Spr 1	FIN	Saltvik	Östra Jansmyra I	6186	120	-26,80	Ua-17856	6186	120	ccr	Stenbäck 2003	ÅM 635: 1
Spr 1	RUS		Veksa 3	6185	30	-30,26	KIA-33927	6185	30	ccr	Piezonka 2008	
Spr 1	FIN	Saltvik	Vargstensslätten II	6165	75	-26,40	Ua-17859	6165	75	ccr	Stenbäck 2003	ÅM 472: 483

Spr 1	FIN	Kitee	Koivikko	6117	44	-30,10	Hela-2953	6117	44	ccr	Paper III	KM 13014
Spr 1	FIN	Saltvik	Östra Jansmyra I	6100	75	-25,70	Ua-17854	**6090**	**75**	ccr	Stenbäck 2003	ÅM 115: 51
Spr 1	RUS		Sulgu 2	6085	30		KIA-36724	6085	30	ccr	Piezonka 2008	
Spr 1	FIN	Saltvik	Östra Jansmyra I	6065	80	-24,80	Ua-17855	**6024**	**82**	ccr	Stenbäck 2003	ÅM 635: 1
Spr 1	FIN	Kouvola	Ankkapurha	6060	60	-26,50	Hela-395	6060	60	ccr	Schulz 2004	KM 31785:1279
Spr 1	RUS		Sulgu 2	6015	30	-26,48	KIA-33925	6015	30	bbt	Piezonka 2008	
Spr 1	FIN	Kokemäki	Kraviojankangas	5992	35		Ua-46149	5992	35	ccr	Pääkkönen et al. 2016	
Spr 1	FIN	Saltvik	Vargstensslätten II	5990	90	-25,80	Ua-17857	**5983**	**90**	ccr	Stenbäck 2003	ÅM 472: 180
Spr 1	FIN	Saltvik	Vargstensslätten II	5990	75	-25,50	Ua-17858	**5973**	**75**	ccr	Stenbäck 2003	ÅM 472: 222
Spr 1	FIN	Saarijärvi	Rusavierto	5985	80	-27,90	Hela-442	5985	80	ccr	Leskinen 2002	KM 32195: 247
Spr 1	FIN	Utajärvi	Roinila	5975	105	-25,60	Hela-149	**5961**	**105**	ccr	Hallgren 2004	KM 13600:3+5
Spr 1	RUS		Uya III	5970	40	-28,77	GrA-63546	5970	40	bbt	Nordqvist & Mökkönen 2016a	
Spr 1	RUS		Orovnavolok V	5945	40	-27,23	GrA-63735	5945	40	bbt	Nordqvist & Mökkönen 2016a	
Spr 1	FIN	Simo	Tainiaro	5940	100	-27,60	Hela-80	5940	100	ccr	Hallgren 2004	KM 22398:342
Spr 1	FIN	Vantaa	Etelä-Vantaa 3	5925	45	-24,80	Ua-32194	**5884**	**49**	ccr	Leskinen & Pesonen 2008	KM 18978: 106
Spr 1	FIN	Simo	Tainiaro	5920	100	-28,60	Hela-79	5920	100	ccr	Hallgren 2004	KM 22398:349
Spr 1	FIN	Porvoo	Böle	5884	43	-26,00	Hela-3177	5884	43	ccr	Paper IV	KM 17074:724
Spr 1	RUS		Sheltozero 5	5870	40	-27,20	GrA-63587	5870	40	ccr	Nordqvist & Mökkönen 2016a	
Spr 1	FIN	Vantaa	Viinikkala 2	5865	55	-26,00	Hela-887	5865	55	ccr	Leskinen & Pesonen 2008	KM 34277:81
Spr 1	RUS	Uusikirkko	Kelonen	5835	40	-26,63	GrA-63528	5835	40	ccr	Nordqvist & Mökkönen 2016a	KM 8699:53
Spr 1	FIN	Kokemäki	Kraviojankangas	5831	36		Ua-46148	5831	36	ccr	Pääkkönen et al. 2016	
Spr 1	RUS	Muolaa	Telkkälä	5830	80	-27,50	Hela-554	5830	80	ccr	Takala & Sirviö 2003	
Spr 1	FIN	Vantaa	Viinikkala 2	5805	50	-25,90	Hela-886	**5802**	**50**	ccr	Leskinen & Pesonen 2008	KM 34277:58
Spr 1	FIN	Kouvola	Ankkapurha	5800	70	-26,10	Hela-394	5800	70	ccr	Schulz 2004	KM 31785:1275
Spr 1	RUS		Panozero 1	5795	35	-26,49	KIA-33924	5795	35	bbt	Piezonka 2008	
Spr 1	FIN	Loimaa	Kojonperä	5790	140	-25,00	Hel-2376	**5756**	**141**	ccr	Luoto & Terho 1988	
Spr 1	FIN	Simo	Tainiaro	5775	40	-27,79	GrA-63483	5775	40	ccr	Nordqvist & Mökkönen 2016a	KM 22398:920
Spr 1	FIN	Oulu	Pahkakoski 1	5770	80	-28,40	Hela-96	5770	80	ccr	Hallgren 2004	KM 14894:221
Spr 1	FIN	Oulu	Pahkakoski 1	5745	130	-26,20	Hela-99	5745	130	ccr	Hallgren 2004	KM 14894:352+245
Spr 1	FIN	Kouvola	Ankkapurha	5650	80	-25,20	Hela-445	**5623**	**81**	ccr	Schulz 2004	KM 32191:2250
Spr 1	RUS	Viipuri	Selänkangas	5639	40	-24,96	GrA-63525	**5603**	**44**	ccr	Nordqvist & Mökkönen 2016a	KM 6114:275
Spr 1	FIN	Oulu	Pahkakoski 1	5615	95	-27,90	Hela-98	5615	95	ccr	Hallgren 2004	KM 14894:310
Spr 1	FIN	Kouvola	Ankkapurha	5595	90	-27,10	Hela-443	5595	90	ccr	Schulz 2004	KM 32191:633
Spr 1	FIN	Saarijärvi	Uimaranta	5590	75	-27,40	Hela-546	5590	75	bbt	Pesonen et al. 2012	KM 32862:593
Spr 1	RUS		Vozmaricha 26	5505	50	-27,63	KIA-35901	5505	50	ccr	Piezonka 2008	
Spr 1	FIN	Raasepori	Timmerkärr	5451	44	-27,50	Hela-3175	5451	44	ccr	Paper IV	KM 31106:185

Spr 1*	FIN	Oulu	Latokangas	2105	30	-30,47	GrA-63515	2105	30	paint	Nordqvist & Mökkönen 2016a	KM 24750:715
Spr 2	FIN	Pielavesi	Kivimäki	5680	40	-29,20	GrA-62077	5680	40	ccr	Nordqvist & Mökkönen 2016a	KM 24465:17d
Spr 2	FIN	Pielavesi	Kivimäki	5675	40	-27,04	GrA-62176	5675	40	ccr	Nordqvist & Mökkönen 2016a	KM 24465:206
Spr 2	FIN	Pielavesi	Kivimäki	5661	43	-28,40	Hela-2873	5661	43	ccr	Paper IV	KM 24465:17
Spr 2	RUS	Pyhäjärvi	Kunnianniemi	5635	45	-30,20	Hela-1817	5635	45	ccr	Seitsonen et al. 2009	
Spr 2	FIN	Simo	Tainiaro	5615	40	-25,56	GrA-63478	**5600**	**41**	ccr	Nordqvist & Mökkönen 2016a	KM 22398:5a
Spr 2	FIN	Raasepori	Timmerkärr	5614	41	-25,90	Hela-3170	**5611**	**41**	ccr	Paper IV	KM 31635:210
Spr 2	FIN	Lappeenranta	Saksanniemi	5599	42	-28,40	Hela-2952	5599	42	ccr	Paper III	KM 12169:63
Spr 2	FIN	Kouvola	Ankkapurha	5590	70	-23,90	Hela-446	**5518**	**78**	ccr	Schulz 2004	KM 32191:1838
Spr 2	RUS	Viipuri	Selänkangas	5550	40	-26,56	GrA-63527	5550	40	ccr	Nordqvist & Mökkönen 2016a	KM 6253:214
Spr 2	FIN	Kouvola	Ankkapurha	5510	60	-26,60	Hela-392	5510	60	ccr	Schulz 2004	KM 31785:491
Spr 2	RUS	Viipuri	Selänkangas	5490	40	-28,32	GrA-63526	5490	40	ccr	Nordqvist & Mökkönen 2016a	KM 6114:275
Spr 2	FIN	Kurikka	Järvimäki	5477	41	-29,70	Hela-3171	5477	41	ccr	Paper IV	KM 27463:1
Spr 2	FIN	Espoo	Kläppkärr	5439	43	-26,00	Hela-3173	5439	43	ccr	Paper IV	KM 31107:399
Spr 2	FIN	Vantaa	Storskogen	5415	45	-25,70	Ua-32193	**5405**	**45**	ccr	Leskinen & Pesonen 2008	KM 9665: 57
Spr 2	FIN	Kouvola	Ankkapurha	5410	75	-26,00	Hela-444	5410	75	ccr	Schulz 2004	KM 32191:684
Spr 2	RUS	Viipuri	Selänkangas	5365	40	-27,50	GrA-63524	5365	40	ccr	Nordqvist & Mökkönen 2016a	KM 6114:198
Spr 2	FIN	Kouvola	Ankkapurha	5360	70	-23,80	Hela-393	**5284**	**79**	ccr	Schulz 2004	KM 31785:1260
Spr 2	FIN	Saarijärvi	Uimaranta	5335	45	-29,40	Hela-642	5335	45	ccr	Paper II	KM 33321:4189
Sär 1	NOR	Nesseby	Nordli	6570	60	-22,8	Tua-3028	**6394**	**95**	ccr	Skandfer 2005; 2009	
Sär 1	RUS		Kalmozero 11	6340	70		KIA-35899#	6340	70	ccr	Piezonka 2008	
Sär 1	NOR	Nesseby	Nordli	6330	50	-22,8	Tua-3021	**6154**	**89**	ccr	Skandfer 2005; 2009	
Sär 1	NOR	Sör-Varanger	Noatun Innmarken	6185	65	-22,9	Tua-3023	**6014**	**98**	ccr	Skandfer 2005; 2009	
Sär 1	FIN	Utajärvi	Pyhänniska	6140	105	-27,5	Hela-148	6140	105	ccr	Torvinen 2000	
Sär 1	FIN	Oulu	Vepsänkangas	6135	40	-26,58	GrA-63484	6135	40	ccr	Nordqvist & Mökkönen 2016a	KM 30561:802
Sär 1	FIN	Oulu	Vepsänkangas	6120	75	-26,3	Hela-236	6120	75	ccr	Torvinen 2000	
Sär 1	RUS		Kalmozero 11	6080	45		KIA-35899#	6080	45	ccr	Piezonka 2008	
Sär 1	NOR	Nesseby	Lossoas hus	6065	55	-23,8	Tua-3024	**5944**	**85**	ccr	Skandfer 2005; 2009	
Sär 1	NOR	Sör-Varanger	Inganeset	6065	55	-24,3	Tua-3025	**5972**	**81**	ccr	Skandfer 2005; 2009	
Sär 1	NOR	Sör-Varanger	Noatun Neset Vest	6030	70	-23	Tua-3026	**5865**	**100**	ccr	Skandfer 2005; 2009	
Sär 1	FIN	Oulu	Latokangas	6010	40	-24,91	GrA-63485	**5973**	**44**	ccr	Nordqvist & Mökkönen 2016a	KM 24377:218+245
Sär 1	FIN	Oulu	Vepsänkangas	5995	65	-22,2	Hela-128	**5864**	**91**	ccr	Torvinen 2000	
Sär 1	FIN	Oulu	Vepsänkangas	5990	60	-27,3	Hela-312	5990	60	bbt	Koivisto 1998	
Sär 1	NOR	Sör-Varanger	Mennikka	5975	60	-24,4	Tua-3027	**5887**	**84**	ccr	Skandfer 2005; 2009	
Sär 1	NOR	Sör-Varanger	Noatun Neset	5950	90		Beta-13126	5950	90	ccr	Skandfer 2005; 2009	
Sär 1	NOR	Sör-Varanger	Noatun Innmarken	5850	55	-21,2	Tua-3929	**5585**	**106**	ccr	Skandfer 2005; 2009	

Sär 1	FIN	Inari	Rönkönraivio	5830	85	-28,2	Hela-38	5830	85	ccr	Torvinen 2000	
Sär 1	FIN	Kemijärvi	Neitilä 4	5800	90	-25,1	Hela-34	**5769**	**91**	ccr	Torvinen 2000	
Sär 1	FIN	Oulu	Latokangas	5795	90	-27	Hela-146	5795	90	ccr	Torvinen 2000	
Sär 1	NOR	Sör-Varanger	Mennikka	5795	55	-22,1	Tua-3022	**5580**	**98**	ccr	Skandfer 2005; 2009	
Sär 1	FIN	Oulu	Latokangas	5790	105	-25,7	Hela-42	**5780**	**105**	ccr	Torvinen 2000	
Sär 1	RUS		Besovy Sledki II	5775	70	-26,76	GrA-63547	5775	70	ccr	Nordqvist & Mökkönen 2016a	No 149/511
Sär 1	FIN	Simo	Tainiaro	5735	40	-26,42	GrA-63480	5735	40	ccr	Nordqvist & Mökkönen 2016a	KM 22398:235
Sär 1	FIN	Rovaniemi	Ylitalo/Toivola	5520	185	-20,3	Hela-40	**5324**	**208**	ccr	Torvinen 2000	
Sär 1	FIN	Rovaniemi	Jokkavaara	5070	80	-25,9	Hela-57	**5067**	**80**	ccr	Torvinen 2000	
Sär 1	FIN	Oulu	Latokangas	5025	35	-27,89	GrA-63486	5025	35	ccr or paint	Nordqvist & Mökkönen 2016a	KM 25731:385
TCW*	RUS		Chernaya Guba III	6060	40	-27,84	GrA-63539	6060	40	ccr	Nordqvist & Mökkönen 2018	AM 2091/856
TCW	FIN	Tervola	Törmävaara	5160	100	-25,60	Hela-78	**5146**	**100**	ccr	Pesonen 2004	KM 21599:453
TCW	FIN	Eura	Kolmhaara	5155	60	-22,50	Hela-362	**5035**	**84**	ccr	Pesonen 2004	KM 15218:197
TCW	RUS		Chernaya Guba III	5155	35	-29,19	GrA-63538	5155	35	ccr	Nordqvist & Mökkönen 2018	AM 2091/338
TCW	FIN	Taipalsaari	Vaateranta	5105	35	-27,06	GrA-62075	5105	35	ccr	Nordqvist 2018	KM 30887:689
TCW	FIN	Oulu	Kierikinkangas	5085	125	-27,20	Hela-409	5085	125	bbt	Pesonen 2004	KM 31829:295
TCW	FIN	Mynämäki	Aisti	5071	42	-24,10	Hela-3077	**5006**	**53**	ccr	Paper IV	KM 16429:15
TCW	FIN	Rääkkylä	Vihi 1	5070	40		Poz-5978	5070	40	bbt	Varonen 2007	KM 30460: 806
TCW	FIN	Joroinen	Kanava	5065	55	-27,60	Hela-848	5065	55	ccr	Schulz 2006	
TCW	FIN	Lieto	Kukkarkoski I	5060	65	-28,50	Hela-118	5060	65	bbt	Pesonen 1999a	KM 19727:89
TCW	FIN	Rääkkylä	Vihi 1	5055	75	-28,30	Hela-250	5055	75	bbt	Pesonen 1999a	KM 30460:2921
TCW	FIN	Raahe	Kauniinmetsänniitty 1	5055	35	-25,86	GrA-63544	**5050**	**35**	ccr	Nordqvist 2018	KM 36937:551
TCW	FIN	Rääkkylä	Vihi 1	5045	45		Poz-5979	5045	45	bbt	Varonen 2007	KM 30460: 2577
TCW	RUS		Sheltozero V	5045	35	-27,99	GrA-63588	5045	35	ccr	Nordqvist & Mökkönen 2018	AM 803/15,81
TCW	FIN	Vantaa	Maarinkunnas	5040	60	-23,20	Hela-356	**4944**	**76**	ccr	Leskinen 2003	KM 30464:7520
TCW	FIN	Joroinen	Kanava	5040	35	-29,13	GrA-62080	5040	35	ccr	Nordqvist 2018	KM 33923:2946
TCW	FIN	Taipalsaari	Vaateranta	5035	70	-27,00	Hela-117	5035	70	bbt	Pesonen 1999a	KM 19239:651
TCW	RUS		Voynavolok XXIX	5030	35	-28,99	GrA-63560	5030	35	bbt	Nordqvist & Mökkönen 2018	AM 223/379
TCW	FIN	Kaustinen	Kangas	5020	65	-26,20	Hela-172	5020	65	ccr	Halinen 1997	
TCW	FIN	Rääkkylä	Pörrinmökki	5020	35	-26,76	GrA-62085	5020	35	bbt	Nordqvist 2018	KM 28013:6101
TCW	FIN	Rovaniemi	Piirittävaara	5015	60	-27,60	Hela-122	5015	60	bbt	Pesonen 1999a	KM 25334:210
TCW	FIN	Kitee	Sarvisuo	5005	70	-27,90	Hela-152	5005	70	bbt	Pesonen 1999a	KM 29714:125
TCW	FIN	Joroinen	Kanava	4995	45	-28,50	Hela-703	4995	45	bbt	Schulz 2006	
TCW	FIN	Pihtipudas	Madeneva	4995	95	-29,40	Hela-322	4995	95	ccr	Miettinen 2002	KM 30978:153-156
TCW	FIN	Outokumpu	Sätös	4990	70	-27,40	Hela-116	4990	70	bbt	Pesonen 1999a	KM 18225:308
TCW	FIN	Outokumpu	Lintutorni	4990	60	-27,00	Hela-224	4990	60	bbt	Karjalainen 2002	KM 30319:1403

TCW	FIN	Oulu	Kuuselankangas	4990	35	-25,91	GrA-63491	**4987**	**35**	ccr	Mökkönen & Nordqvist 2018	KM 30666:1083
TCW	FIN	Outokumpu	Lintutorni	4985	75	-25,70	Hela-227	4985	75	bbt	Karjalainen 2002	KM 30319:832
TCW	FIN	Rääkkylä	Vihi 1	4980	80		Poz-5980	4980	80	bbt	Varonen 2007	KM 30460: 3264
TCW	FIN	Rääkkylä	Vihi 1	4980	65	-29,10	Hela-765	4980	65	ccr	Paper III	KM 30460:1925
TCW	FIN	Rääkkylä	Pörrinmökki	4975	60	-26,60	Hela-123	4975	60	bbt	Pesonen 1999a	KM 28013:9374
TCW	FIN	Outokumpu	Lintutorni	4970	60	-29,40	Hela-223	4970	60	bbt	Karjalainen 2002	KM 30319:746
TCW	FIN	Taipalsaari	Kujansuu	4970	80	-27,60	Hela-410	4970	80	bbt	Pesonen 2004	KM 31825:231
TCW	RUS	Muolaa	Telkkälä	4965	80	-27,00	Hela-553	4965	80	ccr	Takala & Sirviö 2003	
TCW	FIN	Outokumpu	Sätös	4965	35	-27	GrA-62064	4965	35	bbt	Nordqvist 2018	KM 28482:2449
TCW	FIN	Rääkkylä	Pörrinmökki	4960	35	-28,88	GrA-62081	4960	35	bbt/ccr	Nordqvist 2018	KM 28013:590
TCW	RUS	Outokumpu	Sätös	4960	35	-27,98	GrA-62062	4960	35	bbt	Nordqvist 2018	KM 28482:2483
TCW	FIN	Outokumpu	Lintutorni	4950	60	-27,60	Hela-226	4950	60	bbt	Karjalainen 2002	KM 30319:756
TCW	FIN	Kotka	Niskasuo	4950	35	-23,60	Hela-1649	**4868**	**53**	ccr	Paper IV	
TCW	FIN	Liperi	Jyrinlahti 1-4	4945	70	-27,10	Hela-364	4945	70	bbt	Pesonen 2004	KM 29548:1
TCW	FIN	Tervola	Törmävaara	4945	70	-23,70	Hela-107	**4866**	**80**	ccr	Pesonen 2004	KM 22481:2236
TCW	FIN	Tervola	Törmävaara	4940	75	-24,00	Hela-105	**4871**	**82**	ccr	Pesonen 2004	KM 22070:1067
TCW	FIN	Vantaa	Maarinkunnas	4940	60	-22,50	Hela-357	**4820**	**84**	ccr	Leskinen 2003	KM 30464:11228
TCW	FIN	Raahe	Kauniinmetsänniitty 1	4935	35	-28,49	GrA-63542	4935	35	ccr	Nordqvist 2018	KM 39637:652
TCW	FIN	Rääkkylä	Vihi 1	4930	35		Poz-6195	4930	35	bbt	Varonen 2007	KM 30460: 3264
TCW	RUS	Pyhäjärvi	Kunnianniemi	4930	35	-25,40	Hela-1816	**4910**	**36**	ccr	Seitsonen et al. 2009	
TCW	RUS		Chernaya Guba III	4925	35	-26,94	GrA-63540	4925	35	bbt	Nordqvist & Mökkönen 2018	AM 2226/593
TCW	FIN	Pieksämäki	Naarajärvi	4920	60	-28,40	Hela-119	4920	60	bbt	Pesonen 1999a	KM 21519:412
TCW	FIN	Vantaa	Sandåker	4920	45	-19,90	Ua-32198	**4710**	**112**	ccr	Leskinen & Pesonen 2008	KM 26173: 1508
TCW	FIN	Rääkkylä	Pörrinmökki	4915	65	-28,30	Hela-150	4915	65	bbt	Pesonen 1999a	KM 29713:289
TCW	FIN	Jyväskylä	Peuha	4910	60	-28,50	Hela-121	4910	60	bbt	Pesonen 1999a	KM 22900:260
TCW	FIN	Rääkkylä	Pörrinmökki	4910	25	-27,67	GrA-62132	4910	25	bbt	Nordqvist 2018	KM 28013:5386
TCW	FIN	Taipalsaari	Kujansuu	4905	65	-27,90	Hela-411	4905	65	bbt	Pesonen 2004	KM 31825:664
TCW	FIN	Kalajoki	Kivimaa	4905	35	-26,75	GrA-63516	4905	35	ccr	Nordqvist 2018	KM 23381:357
TCW	FIN	Raahe	Kauniinmetsänniitty 1	4895	35	-26,1	GrA-63546	4895	35	ccr	Nordqvist 2018	KM 36937:226
TCW	RUS		Chernaya Guba III	4895	35	-28,07	GrA-63537	4895	35	bbt	Nordqvist & Mökkönen 2018	AM 1677/33
TCW	FIN	Mikkeli	Neulaportti	4885	60	-27,00	Hela-120	4885	60	bbt	Pesonen 1999a	KM 22117:32
TCW	FIN	Vantaa	Maarinkunnas	4880	60	-21,40	Hela-256	**4722**	**98**	ccr	Leskinen 2003	KM 30464:12889
TCW	FIN	Savonlinna	Pääskylahti	4875	70	-28,00	Hela-112	4875	70	bbt	Pesonen 1999a	KM 8787:108
TCW	FIN	Kangasala	Sarsa	4875	70	-27,10	Hela-363	4875	70	bbt	Pesonen 2004	KM 17340:488
TCW	FIN	Vantaa	Sandåker	4875	45	-21,80	Ua-32197	**4730**	**84**	ccr	Leskinen & Pesonen 2008	KM 26173: 702
TCW	FIN	Joroinen	Kanava	4870	45	-28,20	Hela-705	4870	45	bbt	Schulz 2006	

TCW	FIN	Ruokolahti	Karoniemi	4860	110	-27,50	Hela-450	4860	110	ccr	Paper IV	
TCW	FIN	Oulu	Kierikin sorakuoppa	4850	35	-25,54	GrA-63488	**4830**	**36**	ccr	Mökkönen & Nordqvist 2018	KM 23728:682
TCW	FIN	Oulu	Kierikin sorakuoppa	4850	35	-25,54	GrA-63488	**4834**	**36**	ccr	Mökkönen & Nordqvist 2018	KM 23728:682
TCW	FIN	Rääkkylä	Vihi 1	4845	45	-28,36	GrA-62070	4845	45	bbt	Nordqvist 2018	KM 30460:4902
TCW	FIN	Rääkkylä	Vihi 1	4840	80	-27,20	Hela-251	4840	80	bbt	Pesonen 1999a	KM 30460:5589
TCW	FIN	Joroinen	Kanava	4840	45	-27,90	Hela-704	4840	45	bbt	Schulz 2006	
TCW	FIN	Tervola	Törmävaara	4840	140	-26,20	Hela-106	4840	140	ccr	Pesonen 2004	KM 22070:1257
TCW	FIN	Outokumpu	Lintutorni	4830	60	-28,20	Hela-225	4830	60	bbt	Karjalainen 2002	KM 30319:549
TCW	FIN	Nousiainen	Kukonharja 2	4829	40	-18,20	Hela-3178	**4560**	**137**	ccr	Paper IV	KM 38207:21
TCW	FIN	Lapinlahti	Kärkkäinen	4820	70	-28,30	Hela-111	4820	70	bbt	Pesonen 1999a	KM 8603:7
TCW	FIN	Oulu	Kierikinkangas	4820	65	-27,20	Hela-408	4820	65	bbt	Pesonen 2004	KM 31829:440
TCW	FIN	Pihtipudas	Madeneva	4810	70	-27,20	Hela-113	4810	70	bbt	Pesonen 1999a	KM 16422:28
TCW	FIN	Rääkkylä	Pörrinmökki	4808	39	-27,60	Hela-2874	4808	39	bbt	Paper III	KM 27195:1
TCW	RUS		Solomanni	4802	39	-27,70	Hela-2582	4802	39	bbt	Paper IV	KM 11369:1
TCW	FIN	Oulu	Kierikin sorakuoppa	4790	35	-27,36	GrA-63487	4790	35	bbt	Mökkönen & Nordqvist 2018	KM 23432:782
TCW	FIN	Oulu	Kierikin sorakuoppa	4790	35	-27,36	GrA-63487	4790	35	bbt	Mökkönen & Nordqvist 2018	KM 23432:782
TCW	FIN	Rääkkylä	Vihi 1	4785	65	-27,90	Hela-252	4785	65	bbt	Pesonen 1999a	KM 30460:2023
TCW	FIN	Rääkkylä	Vihi 1	4785	55	-28,30	Hela-766	4785	55	bbt	Paper III	KM 30460:4967
TCW	FIN	Raahe	Kauniinmetsänniitty 1	4770	40	-29,60	Hela-1712	4770	40	bbt	Pesonen 2013	
TCW	FIN	Kalajoki	Kivimaa	4765	45	-26,08	GrA-63517	4765	45	ccr	Nordqvist 2018	KM 23381:194
TCW	FIN	Vantaa	Maarinkunnas	4745	60	-27,30	Hela-255	4745	60	bbt	Leskinen 2003	KM 30464:11862
TCW	FIN	Rääkkylä	Vihi 1	4740	70	-28,10	Hela-249	4740	70	bbt	Pesonen 1999a	KM 30460:6875
TCW	FIN	Lapua	Pitkämäki	4740	70	-27,90	Hela-361	4740	70	bbt	Pesonen 2004	KM 14117:31
TCW	FIN	Rääkkylä	Vihi 1	4740	35		Poz-5872	4740	35	bbt	Varonen 2007	KM 30460: 6648
TCW	FIN	Kaustinen	Kangas	4740	60	-27,40	Hela-173	4740	60	ccr	Halinen 1997	
TCW	FIN	Leppävirta	Voutilainen	4730	70	-28,50	Hela-114	4730	70	bbt	Pesonen 1999a	KM 13886:234
TCW	FIN	Raahe	Kauniinmetsänniitty 1	4730	40	-25,40	Hela-1713	**4710**	**41**	ccr	Pesonen 2013	
TCW	FIN	Rääkkylä	Vihi 1	4725	45	-25,90	Hela-2876	**4722**	**45**	ccr	Paper III	
TCW	FIN	Oulu	Kierikinkangas	4715	40	-29,80	Hela-1957	4715	40	bbt	Viljanmaa 2009	
TCW	FIN	Rääkkylä	Vihi 1	4710	70	-28,00	Hela-253	4710	70	bbt	Pesonen 1999a	KM 30460:633
TCW	FIN	Kotka	Niskasuo	4700	75	-26,50	Hela-115	4700	75	bbt	Pesonen 1999a	KM 17075:250
TCW	FIN	Lappeenranta	Murheistenranta	4658	34	-28,60	Ua-51562	4658	34	bbt	Paper IV	KM 37963:62
TCW	FIN	Taipalsaari	Kujansuu	4390	60	-23,62	GrA-62507	4390	60	ccr	Nordqvist 2018	KM 31825:696
UCW	FIN	Puumala	Kärmelahti	4730	50	-26,82	GrA-62488	4730	50	bbt	Nordqvist 2018	KM 31376:706
Voy	FIN	Inari	Vuopaja	4805	85	-26,01	Ua-4364	4805	85	ccr	Tarasov et al. 2017	KM 9125: 1
Voy	RUS		Pervomayskaya I	4710	35	-27,14	GrA-63682	4710	35	ccr	Nordqvist & Mökkönen 2018	AM 2410/9

Voy	RUS		Voynavolok XXXI	4693	35	-26	Hela-2428	4693	35	ccr	Nordqvist & Mökkönen 2018	
Voy	RUS		Fofanovo XIII	4685	35	-28,03	GrA-62060	4685	35	ccr	Nordqvist & Mökkönen 2018	AM 3301/4753-4759
Voy	RUS		Pervomayskaya I	4685	35	-27,85	GrA-63592	4685	35	ccr	Nordqvist & Mökkönen 2018	AM 2410/81
Voy	FIN		Pervomayskaya I	4615	35	-27,92	GrA-63683	4615	35	ccr	Nordqvist & Mökkönen 2018	AM 2410/421
Voy	RUS		Pervomayskaya I	4610	35	-27,68	GrA-63590	4610	35	ccr	Nordqvist & Mökkönen 2018	AM 2410/135
Voy	RUS		Voynavolok XXVII	4605	35	-27,49	GrA-63565	4605	35	ccr	Nordqvist & Mökkönen 2018	AM 2PGU/1458
Voy	RUS		Fofanovo XIII	4585	35	-27,5	GrA-62059	4585	35	ccr	Nordqvist & Mökkönen 2018	AM 3301/5141
Voy	RUS		Fofanovo XIII	4585	60	-30	GrA-62484	4585	60	ccr	Nordqvist & Mökkönen 2018	AM 3301/4818
Voy	RUS		Fofanovo XIII	4454	42	-27,5	Hela-2812	4454	42	ccr	Zhulnikov et al. 2012	
Voy	RUS		Voynavolok XXVII	4365	35	-28,15	GrA-63562	4365	35	ccr	Nordqvist & Mökkönen 2018	AM 2PGU/1473
Zal	RUS		Zolotets XX	4610	35	-28,16	GrA-63550	4610	35	bbt	Nordqvist & Mökkönen 2018	AM 284/833
Zal	RUS		Zalavruga I	4580	35	-29,15	GrA-63559	4580	35	ccr	Nordqvist & Mökkönen 2018	AM 378/297
Zal	RUS		Zalavruga I	4570	35	-25,3	GrA-63551	4570	35	ccr	Nordqvist & Mökkönen 2018	AM 281/455
Zal	RUS		Zalavruga I	4495	35	-27,2	GrA-63555	4495	35	ccr	Nordqvist & Mökkönen 2018	AM 378/532
Zal	RUS		Zalavruga I	4295	35	-26,13	GrA-63552	4295	35	ccr	Nordqvist & Mökkönen 2018	AM 281/38
Kiuk	FIN	Turku	Niuskala				GrA-12392	4000	70	ccr	Asplund 2008	
Kiuk	FIN	Turku	Niuskala				GrA-12393	3910	70	ccr	Asplund 2008	
Kiuk	FIN	Turku	Niuskala				GrA-14113	3825	35	ccr	Asplund 2008	
Kiuk	FIN	Dragsfjärd	Hammarsboda				GrA-14114	3625	35	ccr	Asplund 2008	
Kiuk	FIN	Vammala	Hiukkasaari			-25,20	Hela-261	3700	65	ccr	Luoto 2004	TYA 178:363
Kiuk	FIN	Eurajoki	Etukämppä			-25,10	Hela-770	3785	50	ccr	Lehtonen 2005	KM 34005:569
Kiuk	FIN	Harjavalta	Saamanmäki			-21,40	Hela-1122	3845	40	ccr	unpublished	KM 35299:27
Kiuk	FIN	Kristiinankaupunki	Lappfjärd-Norrviken				Hela-4415	3921	18	ccr	unpublished	KM 20109:3
Kiuk	FIN	Kristiinankaupunki	Lappfjärd-Kyttåkersbacken				Hela-4416	3722	17	ccr	unpublished	KM 21001:6
Kiuk	FIN	Harjavalta	Kraakanmäki 2			-16,10	ICA-14C/1109	3570	40	ccr	unpublished	KM 39895:143
Kiuk	FIN	Harjavalta	Kraakanmäki 2			-23,00	Ua-49740	3518	38	ccr	unpublished	KM 39895:143

Appendix III. Radiocarbon dates connected with Säräisniemi 1 Ware.

Abbreviations. Cultural context: Sär 1 = Säräisniemi 1 Ware. Country: FIN = Finland, NOR = Norway, RUS = Russia. Material: coal = charcoal, ccr = charred crust, resin = “chewing resin” i.e. birch bark tar. MRE corrected dates are in bold.

Cultural context	Country	Municipality	Site	C14 age BP	C14 age error (yr)	δ13C	Labcode	MRE corrected	MRE error	Material	Reference	Catalogue number
Sär 1	FIN	Rovaniemi	Jokkavaara	6200	110	-23,40	Hel-3026	6200	110	coal	Torvinen 2000	KM 25709:196
Sär 1	FIN	Oulu	Vepsänkangas	6170	90	-25,90	Hel-4127	6170	90	coal	Hallgren 2008	
Sär 1	FIN	Sotkamo	Kiikarusniemi	6150	110		Hel-1750	6150	110	coal	Torvinen 2000	
Sär 1	FIN	Rovaniemi	Jokkavaara	6110	110		Hel-1620	6110	110	coal	Torvinen 2000	KM 21307:4
Sär 1	FIN	Inari	Nellimjoensuu	6000	120	-26,30	Hel-2678	6000	120	coal	Torvinen 2000	
Sär 1	FIN	Rovaniemi	Jokkavaara	5940	100	-25,40	Hel-3029	5940	100	coal	Torvinen 2000	KM 25709:199
Sär 1	FIN	Rovaniemi	Jokkavaara	5930	150	-24,00	Hel-3025	5930	150	coal	Torvinen 2000	KM 25709:195
Sär 1	FIN	Rovaniemi	Jokkavaara	5850	110		Hel-1619	5850	110	coal	Torvinen 2000	KM 21307:3
Sär 1	FIN	Posio	Kuorikkikangas	5750	110	-26,30	Su-2681	5750	110	coal	Pesonen 2006	
Sär 1	FIN	Rovaniemi	Jokkavaara	5660	130	-25,20	Hel-3030	5660	130	coal	Torvinen 2000	KM 25709:200
Sär 1	FIN	Rovaniemi	Jokkavaara	5650	140	-26,00	Hel-3028	5650	140	coal	Torvinen 2000	KM 25709:198
Sär 1	FIN	Rovaniemi	Jokkavaara	5620	130	-25,70	Hel-3027	5620	130	coal	Torvinen 2000	KM 25709:197
Sär 1	FIN	Sotkamo	Räätäkangas	5440	100		Hel-2294	5440	100	coal	Torvinen 2000	
Sär 1	NOR	Nesseby	Nordli	6570	60	-22,80	Tua-3028	**6394**	**95**	ccr	Skandfer 2003	
Sär 1	RUS		Kalmozero 11	6340	70	-28,82	KIA-35899	6340	70	ccr	Piezonka 2008	
Sär 1	NOR	Nesseby	Nordli	6330	50	-22,80	Tua-3021	**6154**	**89**	ccr	Skandfer 2003	
Sär 1	FIN	Utajärvi	Pyhänniska	6140	105	-27,50	Hela-148	6140	105	ccr	Torvinen 2000	KM 11762:37
Sär 1	FIN	Oulu	Vepsänkangas	6135	40	-26,58	GrA-63484	6135	40	ccr	Nordqvist & Mökkönen 2016a	KM 30561:802
Sär 1	FIN	Oulu	Vepsänkangas	6120	75	-26,30	Hela-236	6120	75	ccr	Torvinen 2000	KM 30561:802
Sär 1	RUS		Veksa 3	6105	30	-30,35	KIA-33928	6105	30	ccr	Piezonka 2008	
Sär 1	RUS		Kalmozero 11	6080	45	-27,75	KIA-35899	6080	45	ccr	Piezonka 2008	
Sär 1	NOR	Sör-Varanger	Noatun Innmarken	6185	65	-22,90	Tua-3023	**6014**	**98**	ccr	Skandfer 2003	
Sär 1	NOR	Sör-Varanger	Inganeset	6065	55	-24,30	Tua-3025	**5972**	**81**	ccr	Skandfer 2003	

Sär 1	FIN	Oulu	Latokangas	6010	40	-24,91	GrA-63485	**5965**	**43**	ccr	Nordqvist & Mökkönen 2016a	KM 24377:218+245
Sär 1	NOR	Sör-Varanger	Noatun Neset	5950	90	0,00	Beta-13126	5950	90	ccr	Skandfer 2003	
Sär 1	NOR	Nesseby	Lossoas hus	6065	55	-23,80	Tua-3024	**5944**	**85**	ccr	Skandfer 2003	
Sär 1	NOR	Sör-Varanger	Mennikka	5975	60	-24,40	Tua-3027	**5887**	**84**	ccr	Skandfer 2003	
Sär 1	NOR	Sör-Varanger	Noatun Neset Vest	6030	70	-23,00	Tua-3026	**5865**	**100**	ccr	Skandfer 2003	
Sär 1	FIN	Oulu	Vepsänkangas	5995	65	-22,20	Hela-128	**5864**	**91**	ccr	Koivisto 1998	KM 24714:4
Sär 1	FIN	Inari	Rönkönraivio	5830	85	-28,20	Hela-38	5830	85	ccr	Torvinen 2000	KM 24931
Sär 1	FIN	Oulu	Latokangas	5795	90	-27,00	Hela-146	5795	90	ccr	Torvinen 2000	KM 25731:698
Sär 1	FIN	Oulu	Latokangas	5790	105	-25,70	Hela-42	**5780**	**105**	ccr	Torvinen 2000	KM 25731:385
Sär 1	RUS		Besovy Sledki II	5775	70	-26,76	GrA-63547	5775	70	ccr	Nordqvist & Mökkönen 2016a	No 149/511
Sär 1	FIN	Kemijärvi	Neitilä 4	5800	90	-25,10	Hela-34	**5769**	**91**	ccr	Torvinen 2000	KM 16553:912
Sär 1	FIN	Simo	Tainiaro	5735	40	-26,42	GrA-63480	5735	40	ccr	Nordqvist & Mökkönen 2016a	KM 22398:235
Sär 1	NOR	Sör-Varanger	Noatun Innmarken	5850	55	-21,20	Tua-3929	**5585**	**106**	ccr	Skandfer 2003	
Sär 1	NOR	Sör-Varanger	Mennikka	5795	55	-22,10	Tua-3022	**5580**	**98**	ccr	Skandfer 2003	
Sär 1	FIN	Rovaniemi	Turpeenniemi	5520	185	-20,30	Hela-40	**5324**	**208**	ccr	Torvinen 2000	KM 14278: 1435
Sär 1	FIN	Rovaniemi	Jokkavaara	5070	80	-25,90	Hela-57	**5067**	**80**	ccr	Torvinen 2000	KM 21012:34
Sär 1	FIN	Oulu	Latokangas	5025	35	-27,89	GrA-63486	5025	35	paint	Nordqvist & Mökkönen 2016a	KM 25731:385
Sär 1	FIN	Oulu	Vepsänkangas	6065	75	-27,50	Hela-235	6065	75	resin	Torvinen 2000	KM 30561:269
Sär 1	FIN	Oulu	Vepsänkangas	6020	80	-27,20	Hela-129	6020	80	resin	Koivisto 1998	KM 24714:12
Sär 1	FIN	Oulu	Vepsänkangas	5990	60	-27,30	Hela-312	5990	60	resin	Koivisto 1998	KM 31036:868